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INTERNATIONAL JOURNAL OF COMPARATIVE PSYCHOLOGY

Volume 1, Number 2

Winter 1987

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THE INTERNATIONAL JOURNAL OF COMPARATIVE PSYCHOLOGY is co-sponsored by the International Society for Comparative Psychology, an affiliate of the International Union of Psychological Sciences and the University of Calabria, Italy. In consonance with the goals and activities of the Society, it publishes reports of studies in the evolution and development of behavior of all species; on the use of the comparative method for the understanding of behavioral processes; and the examination of the adequacy of psychological and evolutionary theories. It accepts articles that deal with historical and contemporary relationships between humans and other animals; that elucidate problems of ecological and behavioral processes in resource management; that explicate fundamental concepts about human evolution; and that present research results and develop theories about the development and evolution of behavior. Articles on the contemporary and historical organization of knowledge about comparative psychology; promoting public education on the evolution and development of behavior; and about the training of students in comparative psychology are also invited. Book reviews; letters discussing published articles with replies by authors; notices of new books, journals, meetings and competitions or other matters of interest to the readers will be published at the discretion of the editors. The Editor and Co-Editor are elected by the Operations Committee of the Society. National Editors are appointed by the Editors and the Operations Committee.

MANUSCRIPTS should be submitted in triplicate to the National Editor; if there is none, the three copies should be sent to Ethel Tobach, Editor. See inside back cover for style requirements.

SUBSCRIPTIONS are on an annual basis: \$75.00 per volume for institutions; \$32.00 for individuals; handling and postage costs to be paid by individuals outside the USA; members of the International Society for Comparative Psychology receive their yearly subscription at the rate of \$24.00 as part of their membership dues. For membership information, write to the National Editor or to Dr. John A. Barlow, Treasurer, ISCP, Kingsborough Community College, 2001 Oriental Blvd., Brooklyn, New York, 11235.

ADVERTISING and subscription inquiries should be made to the Business Office: Human Sciences Press, Inc., 72 Fifth Avenue, New York, NY 10011; (212) 243-6000.

INDEXED OR ABSTRACTED IN: Index to Periodical Literature on Aging, Family Resources Database.

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POSTMASTER: Send change of address and return journals if undeliverable to: Circulation, Human Sciences Press, 72 Fifth Avenue, New York, NY 10011. Please return entire journal—do not remove cover.

THE COMPARATIVE PSYCHOLOGY OF LEONARD T. HOBHOUSE: ITS CONTEXT AND CONCEPTION

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University of Victoria

ABSTRACT: Hobhouse viewed comparative psychology as playing a key role in his politically liberal, social-ethical worldview. The main feature of evolving mind was the increased capacity for democratic self-direction. Political reaction, identified with imperialism, attempts ideologically to obscure this fact, and thus to impede social progress. Its instruments are philosophical idealism and pseudo-scientific biologism or Social Darwinism. Comparative psychology, conceived as an essentially human psychology, could counteract this reactionary ideology with genuine scientific knowledge of present human capacity and future potential. These can only be revealed by a correct scientific approach, which, Hobhouse maintained, had to be evolutionary and comparative.

... I have long felt that the prevailing tendency to regard all the marked distinctions of human character as innate, and in the main indelible, and to ignore the irresistible proofs that by far the greater part of those differences, whether between individuals, races, or sexes, are such as not only might but naturally would be produced by differences in circumstances, is one of the chief hindrances to the rational treatment of great social questions, and one of the greatest stumbling blocks to human improvement.

John Stuart Mill, 1873

The doctrine that human progress depends upon the forces which condition all biological evolution has in fact been the primary intellectual cause of the [social-political] reaction.

Leonard T. Hobhouse, 1904

Most comparative psychologists know that Leonard T. Hobhouse (1864–1929) wrote a book called *Mind in Evolution* (1901/1926) in which he described some problem solving techniques for the investigation of learning and “practical intelligence” in animals, techniques which Wolfgang Köhler borrowed—with proper acknowledgement—and improved upon in his well known work on the *Mentality of Apes* (1917/1925). It is probably safe to surmise that acquaintance with Hobhouse is limited

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for many to these few details. More can hardly be expected, considering that the influential textbook of Warden, Jenkins and Warner (1934) mentioned Hobhouse merely as someone who had invented some clever problem-solving methods. Regarding the substance of his investigations, they reported simply that "his results were far from convincing" (p. 559). Edwin G. Boring (1950) disposed of Hobhouse in two sentences relating that he did experiments like those of Lloyd Morgan and Köhler, but that he lacked "the added significance of being related to a new system of psychology" (p. 475). J. C. Flugel (1964) gave Hobhouse a single, even less informative sentence, a bare mention of his surname and title of his book, in passing from Lloyd Morgan to Loeb (p. 102). The majority of more recent textbooks on the history of psychology do not mention him at all. (Notable exceptions are Thomson, 1968, and Murray, 1983, both of whom have evidently taken the trouble to read all or a good part of *Mind in Evolution*.)

Hobhouse might have been treated with such indifference because his work was in fact "not convincing," because he offered no "new system of psychology," or because he simply had little of interest or importance to say. I maintain, however, that he fails on none of these counts. The reasons for his invisibility have had more to do with the *kind* of theory he was proposing, coupled with a general historical turn at the end of the 19th century toward the hegemony of a contrary conception of science and psychology, a conception with which we now associate neopositivism and behaviorism. The fact that this latter hegemony is now manifestly in decline should be taken as an opportunity to reexamine the systems of thought that it smothered in their early stages of development.

For present day comparative psychology, beset as it is by various forms of crisis, not the least of which is one of identity, the ideas of Leonard Hobhouse are particularly pertinent. He had a very clear idea about the identity and mission of comparative psychology. In support of this he had an equally clear idea of its philosophic, historic, and scientific contexts. Especially remarkable was his understanding of comparative psychology's relevance to the human condition. It is my intention here to outline this conception and its manifold context, confident that much of Hobhouse's thought on these matters remains as pertinent today as it was in his own time. Indeed, we may be in a *better* position today to appreciate what he was trying to do than were his contemporaries.

THE PHILOSOPHIC AND HISTORIC CONTEXTS

The Importance of Evolution

Hobhouse was the last of the 19th century comparative psychologists who intended to develop a general evolutionary theory of mind. Owing to a naive Cartesianism, Darwin did not extend his theory of evolutionary

transmutation to the mind. The less timid materialist Spencer was perfectly happy to do so, but he did it by the crudest of means, reductionism. Romanes, a more sensitive thinker, recognized this as an error and made the first tentative steps toward a theoretical solution to the evolution of mind that was both materialistic and nonreductionist. Lloyd Morgan became well known, at least in theoretical biology if not in comparative psychology, for his further development of nonreductionist theory, which he called "emergentism." These ideas of Morgan were undoubtedly less influential than they might have been had he not abandoned the traditional scientific materialism for a mystified form of Spinozism (for an earlier treatment of these issues, see Tolman, 1987).

It is interesting that both Romanes and Morgan suffered historical fates in comparative psychology similar to Hobhouse's. Each became caricatured, Romanes for the "anecdotal method," Morgan for his "canon," which many behaviorists perversely appropriated as part of their justification for forsaking everything he otherwise stood for. Meanwhile, the substantive theoretical contributions of each of these men were ignored or forgotten.

Yet Hobhouse differed from Romanes and Morgan in that he was not a biologist but a social philosopher, and his motives were not solely scientific. He was concerned with the evolution of mind not for its own sake, but because it posed problems that had to be solved if a scientifically grounded social ethic was to be established. Thus comparative psychology was also not an end in itself; it was seen as an integral part of a larger science of humanity in nature. The overriding concern was with social ethics. But a correct social ethics required a correct metaphysics, understood as epistemology and ontology. "Correct" here meant "scientific," and this, in turn, meant "evolutionary." In his words: "... I was convinced that a philosophy that was to possess more than a speculative interest must rest on a synthesis of experience as interpreted by science, and that to such a synthesis the general conceptions of evolution offered a key" (Hobhouse, 1913/1927, pp. xx-xxi).

Progress and Reaction

The social ethical problem that occupied Hobhouse throughout his life and which provided the unifying element to all of his diverse enquires was, broadly speaking, the "right action" of Socrates. It was, however, a right action more completely *socially* conceived than that of Socrates or of practically all social philosophers writing prior to the late 19th century, with the exception possibly of Karl Marx. The right action that Hobhouse sought was the action of the individual, the community, the nation and its state, and ultimately the whole of earthly humanity in its essential unity. It was right action that was at once ethical, social, and political.

At the heart of this conception of right action was a belief in progress, a social-historical movement toward ever greater harmony both between

human and human, and between human and nature. This meant not only improvements in the means of production, but also in social relations, i.e., in both the production and the distribution of wealth.

Closely linked to social progress, in Hobhouse's view, was the increasing capacity for conscious direction of that progress:

To the fully conscious mind in man everything would lead up, and from it, once formed, all future movement would be derived. This was indeed to assume that along with knowledge there would go control, . . . as the full meaning of the self-conscious mind worked itself out it was seen to imply a grip on those underlying conditions of life which, as long as they remain obscure, thwart human effort and distract man from that social collaboration which is necessary to the greatest efforts (Hobhouse, 1913/1927, p. xxii).

Now it seemed to me that it was precisely on this line that modern civilization has made its chief advance, that through science it is beginning to control the physical conditions of life, and that on the side of ethics and religion it is forming those ideas of the unity of the race, and of the subordination of the law, morals and social constitutions generally to the needs of human development which are the condition of the control that is required. (Hobhouse, 1913/1927, pp. xxiv-xxv).

The early middle 19th century was a period of comparatively great social progress in Britain. A succession of liberalizing social and political reforms began in the 1820s and had achieved considerable momentum in the following decade with the passage of the first Reform Act in 1832, an act that "extended political power to new social classes" (Trevelyan, 1959, p. 474). Hobhouse summarized this period as follows:

The sixty years which followed the Battle of Waterloo formed a period of fairly rapid social progress correlated with an advance of social and moral science. Political enfranchisement, the reform of the Government services, Free Trade, the progressive regulation of the new industrial system, the abolition of negro slavery, the removal of the most barbarous features of the criminal law—these and many other reforms were all part of a great humanizing movement stimulated and guided by the thought of the day (Hobhouse, 1904, pp. 57-58).

In many ways this period marked the completion of the bourgeois revolution begun in the 17th century. In Hobhouse's view this was a turning point for the development of conscious direction of social progress. Writing in 1904, however, Hobhouse observed: "During some twenty, or it may be thirty years, a wave of reaction has spread over the civilized world and invaded one department after another of thought and action." But, he went on: "This is no unprecedented occurrence. In the onward movement of mankind, history shows us each forward step followed by a pause, and too often by a backsliding in which the ground gained is lost" (Hobhouse, 1904, p. 2). Hobhouse literally devoted

his life to the prevention of such a loss. Surely if the reaction itself were understood and struggled against, it could be overcome and, in the future, prevented.

By Hobhouse's analysis the root cause of the reaction at home was imperialism abroad:

Little by little it became clearer that the new Imperialism stood, not for a widened and ennobled sense of national responsibility, but for a hard assertion of racial supremacy and material force . . . The central principle of Liberalism is self-government. The central principle of Imperialism, whatever words may be used to cloak it, is the subordination of self-government to Empire (Hobhouse, 1904, pp. 45, 47).

Liberal democracy and freedom could not survive in Britain linked to illiberal autocracy and repression in the colonies. In Hobhouse's view, the subordination of self-government could not be confined to the colonies.¹

Idealism and Reductionism

Imperialism, according to Hobhouse, had two important ideological supports: *philosophical idealism* and *biologistic reductionism*. These may appear to be quite separate, but they prove in the end to be essentially related. This relationship was intuited by J. S. Mill in 1873. As can be seen in the epigram above, Mill saw the belief in "human character as innate" as "one of the greatest stumbling blocks to human improvement." He continued:

This tendency has its source in the intuitional metaphysics which characterized the reaction of the nineteenth century against the eighteenth, and it is a tendency so agreeable to human indolence, as well as to the conservative interests generally, that unless attacked at the very root, it is sure to be carried to even a greater length than is really justified by the more moderate forms of the intuitional philosophy (Mill, 1873/1944, p. 192).

The connections between idealism, biologism and reaction were left by Mill as unelaborated observations. By the end of the century the reaction of "conservative interests" had indeed been "carried to even greater lengths" and the connections were rediscovered and worked out in somewhat greater detail by Hobhouse.

Hobhouse's assessment of philosophical idealism can hardly be expressed more economically or cogently than when he wrote:

The most popular philosophy of our time has had a reactionary influence, the extent of which is perhaps not generally appreciated. For thirty years and more English thought has been subject, not for the first time in its

modern history, to powerful influences from abroad. The Rhine has flowed into the Thames, at any rate into those upper reaches of the Thames, known locally as the Isis, and from the Isis the stream of German idealism has been diffused over the academical world of Great Britain. It would be natural to look to an idealistic philosophy for a counterpoise to those crude doctrines of physical force which we shall find associated with the philosophy of science. Yet, in the main, the idealistic movement has swelled the current of retrogression. It is itself, in fact, one expression of the great reaction against the plain, human, rationalistic way of looking at life and its problems. Every institution and every belief is for it alike a manifestation of a spiritual principle, and thus for everything there is an inner and more spiritual interpretation. Hence, vulgar and stupid beliefs can be held with a refined and enlightening meaning, known only to him who so holds them, a convenient doctrine for men of a highly-rarified understanding, but for those of coarser texture who learn from them apt to degenerate into charlatanism. Indeed, it is scarcely too much to say that the effect of idealism on the world in general has been mainly to sap intellectual and moral sincerity, to excuse men in their consciences for professing beliefs which on the meaning ordinarily attached to them they do not hold, to soften the edges of all hard contrasts between right and wrong, truth and falsity, to throw a gloss over stupidity, and prejudice, and caste and tradition, to weaken the bases of reason, and disincite men to the searching analysis of their habitual ways of thinking. In these ways idealism has had a more subtly retrograde influence than any of the cruder creeds which it condemns, and has thus prepared the way for the scepticism which has been the popular philosophy of the last ten years. To judge by the popularity of teaching of this kind, what people who think a little mainly want at the present day is to be told that they need not follow where their own reason takes them. There is, they are glad to be assured, no logical foundation for the certainty which the sciences claim. Still less is there any rational groundwork of morality, in particular for that humanitarian morality, which they have found so exacting. They can, therefore, with a lightened conscience revert to the easy rule of authority and faith, a rule particularly attractive to a society which has become afraid of further progress and is lusting after the delights of barbarism (Hobhouse, 1904, pp. 77-80).

This is a powerful and, I believe, entirely correct indictment of idealism and its connection to conservatism, reaction, and—as he put it—barbarism. More needs hardly be said on the topic. But what of Hobhouse's own position? He eschewed materialism as well, but when he spoke of it, he was referring to the crude reductionistic and mechanical materialism that was coming to be rejected by most thoughtful scientists and philosophers of the late 19th century. He called his own position "rationalism," which is ontologically uninformative, possibly even misleading, since the label is an epistemological one. An assessment of his metaphysics independent of his own labeling of it reveals an eclecticism with a predominantly materialist caste to it. Where it is forceful and

effective it is transparently materialistic, as his remarks on idealism appear to suggest it ought to be. But Hobhouse had his obscure and evasive moments in which he slipped into a barely disguised, though always objective, idealism.

Although Hobhouse's critique obviously applied to the Kantian strain of idealism, it was Hegel whom he viewed as the greatest culprit. But he could not condemn Hegel without some ambivalence, and this turns out to be very important. Speaking of Hobhouse's doctrine of stages in the evolution of consciousness, Barnes noted: "Hobhouse admits the broad similarity of this doctrine and that of Hegel and holds that he accepts the element of truth advanced by Hegel, while rejecting his metaphysical vagaries and his contention that reality is entirely spiritual" (1948, p. 616). And what, precisely, was this "element of truth?" According to Hearnshaw: "Hobhouse, in spite of his quarrel with the idealist metaphysic, remained faithful to the idealist logic" (Hearnshaw, 1966, p. 17). Barnes described it as "Hegel's doctrine of the development of consciousness" (Barnes, 1948, p. 617). Both are referring to Hegel's dialectic. This is what allowed Hobhouse to retain a species of scientific materialism while avoiding the traps of mechanism and reductionism. Hobhouse's philosophical solutions to these problems were remarkably similar to those of Marx and Engels.

For Hobhouse biologism was epitomized in the doctrines of Herbert Spencer and of those who judged themselves to be Spencerians. Barnes summarized Hobhouse's opposition to Spencer:

Spencer held that the course of evolution moves on automatically, regardless of the interference of man. He believed that the latter could, at least, have only an indifferent effect and was extremely likely to hinder the process. Hobhouse claimed, on the contrary, that however much the evolutionary process may depend upon automatically working factors, such as the struggle for existence, social evolution has come to rest more and more upon conscious control by the human mind. From our period onward, progress will depend primarily upon the conscious direction of the social process by the social mind. Again, while Spencer's conception of the organic nature of society rested upon a wide use of the biological analogy, Hobhouse eschewed the use of technical biological terms and only implied the essential unity and interdependence of social life (Barnes, 1948, p. 614).

The issue underlying Hobhouse's differences with the Spencerians was *reductionism*, a failure on their part to recognize qualitative differences between humans and animals. Hobhouse wrote:

The biological view is that since men are animals the laws regulating human development must be identical with those which we observe in the breeding of shorthorns or of fantailed pigeons. The pigeon fancier should, it appears,

have more to teach us of the conditions of human progress than Gibbon or Mommsen (1904, p. 97).

It was the temptation of an empirical, and in particular of an evolutionary [Spencerian] psychology, to explain away these higher developments of mind, to level distinctions of kind, and so reduce all mental phenomena as nearly as might be to the same level. This, I thought, might be the root of the trouble. . . . (1913/1927, p. xxi).

The "trouble" manifested itself in the failure of the Spencerians to distinguish between evolution and progress. On the one hand, it was clear that not all evolution was "upward" and very often in the struggle for existence the less advanced could and did prevail over the more advanced. On the other hand, human history clearly reveals an upward progress, one which is linked to human values and which biological evolution appears not to be able to explain. "But a little reflection," wrote Hobhouse, "suffices to show that if progress means anything which human beings can value or desire, it depends on the suppression of the struggle for existence, and the substitution in one form or another of social cooperation" (1913/1927, p. xviii).

Further, to believe that progress can be reduced to the "struggle for existence" provided direct support for the kind of reactionary ideology demanded by Imperialism. According to such a doctrine, wrote Hobhouse:

Progress comes about through a conflict in which the fittest survives. It must, therefore, be unwise in the long run—however urgent it seems for the sake of the present generation—to interfere with the struggle. We must not sympathize with the beaten and the weak, lest we be tempted to preserve them. The best thing that can happen is that they should be utterly cut off, for they are the inferior stock, and their blood must not mix with ours. The justice, the mercy, the chivalry, which would induce the conqueror to forbear from enjoying the full fruits of his victory must be looked on with suspicion. It is better to smite the Amalekite hip and thigh and let the conquering race replenish the earth (1904, pp. 85-86).²

What links idealism and biologism is antirationalism, which replaces reason with "authority and faith." If idealism "softens the edges of all hard contrasts between right and wrong, truth and falsity," what is left to restore those edges so desperately needed for decisive action? The rule of force becomes a prime candidate, a force exercised by the powerful, the ruling classes and dominant nations. And what better justification—even tyrants seek to justify themselves—than science itself. "What has filtered through into the social and political thought of the time," wrote Hobhouse, "has been the belief that the time-honoured doctrine 'Might is Right' has a scientific foundation in the laws of biology" (1904, p. 85). The connection between idealism and biologism, then, is not an immediate one, but one mediated by what Marxist analysis identifies as class interest.

Though mediated, the connection is nonetheless, in the case of imperialism, an essential one.

THE SCIENTIFIC CONTEXT

The Role of Comparative Psychology

We are now in a position to understand the key role assigned to comparative psychology in Hobhouse's thinking. His liberalism demanded that he demonstrate precisely that which biologism denied: a real difference of kind between biological evolution and human social progress or history, between what he called the "mechanical" and the "mental." The distinction he had in mind was not a dualistic one, but one asserting simultaneous unity and difference, and the key to achieving that was a correct understanding of evolution and development. He wrote:

Our main object . . . is to exhibit these differences to distinguish the principal types of correlation that are found in the behaviour of living beings. These will be found to range themselves under two great classes of the mechanical and the mental. Even if ultimate analysis should resolve one of these into the other or both into a more ultimate unity, within that unity the distinction would still hold (1901/1926, p. 10).

The first object then, as it seemed to me, was to show that mental evolution had in point of fact consisted in a development of consciousness from stage to stage in the manner supposed. To do this would require a very wide examination on the one hand of animal psychology, on the other of the growth of human thought and of social customs and traditions in which thought is embodied (1913/1927, p. xxv).

In 1911 Hobhouse summarized his conception of comparative psychology and its relationship to biology:

. . . suppose that the species that we chose is Man, and that we put the question in this way: as compared with the lowest organisms from which we assume him to have originated, what is Man? What distance has he traveled? What powers has he acquired? What is the nature of the changes which have brought this species to the birth? Are they changes of degree or changes which though continuous may yet be called changes of kind? What do they portend? Can we infer from the phases that have been passed through anything as to the future? Can we gain any insight into human potentialities? Can we learn anything of man's ultimate place in nature? It is clear that whatever else may be said of these questions they cannot be dismissed as lacking in interest. But for reasons of which we have seen something the biologist as such cannot answer them, and if he is wise does not meddle with them. But they suggest a way of treating

evolutionary problems of which much more will be heard in the future than has been heard hitherto. They suggest the necessity of what I have called a formula of descriptive synthesis, the object of which is to measure the direction and the distance traversed in the evolution of man. By such a measure we arrive at an answer to the question, to put it in a common phrase, of what evolution amounts to. We assess its value. We are able to take a comprehensive and accurate view of what it has done, and we get a firm basis for measuring its further possibilities.

Now the sciences which deal with man from this point of view are two. The first is Comparative Psychology, the second is Sociology. The first is especially concerned with the genesis of the human mind as such. It seeks to determine the stages of development which lead from the first beginnings of psychic life to the emergence of human reason. It seeks for links to connect what at first sight may appear severed and even disparate, but if it is genuinely scientific, it proceeds without any attempt to slur over differences. In this manner it arrives at a true sense of the distance traveled by in the evolution of mind. It has a morphology, too, of its own. The forms in which it is interested are the forms of mental operation, and it seeks to arrange them in such a way as to show how the most elaborate are joined by a series of intermediaries with the most simple. These intermediate phases it finds both in the mind of man itself, where higher and lower operate together, and in various species of the animal world where as it descends the scale it finds the higher functions disappearing one after the other (1911/1968, pp. 115-117).

Comparative Psychology as Human Psychology

Hobhouse's comparative psychology was first and foremost a human psychology, concerned with identifying those aspects of human functioning that distinguish humans from nonhuman animals. These aspects and their characteristics, which prove to be mainly psychological and social, and which Hobhouse called Mind, are revealed through comparison of humans with nonhumans. But Hobhouse did not settle for differences alone. This could easily lead to dualism, and thereby once again to the idealism which he so vigorously resisted. A scientific—as opposed to metaphysical—account of mind must show how it has developed from lower forms of adaptation. It was this emphasis on development that allowed Hobhouse to account for the simultaneous continuity and discontinuity in the relationship between human and nonhuman animals. Hobhouse succeeded in his conception of development largely because he adopted the logic needed to support it, namely the Hegelian dialectic.

As an evolutionary approach to mind, Hobhouse's comparative psychology yielded a theory that was characterized by both stages and levels. Evolution was conceived as having passed through successive stages of which the more advanced was qualitatively distinct from the more primitive, yet quantitatively connected to it through a process of

development. The more primitive, however, is not lost in this process but is preserved so that a more advanced species represents within itself an organization of differing, but ordered levels of functioning.

By far the most important stage or level is that attained by the human species. This is a stage at which the very biological evolutionary process that produced it is transcended and replaced by a new process of change which Hobhouse identified with progress. It is marked by conscious self-determination and social cooperation. Human beings collectively change the world to suit their own developing needs and in so doing change themselves. They become, in a way only vaguely foreshadowed in the more advanced subhuman species, true subjects of their own history.

The course of human historical development is, however, fraught with many pitfalls. From time to time it works to the selfish advantage of certain segments of the human community to work for the arrest of development, to exploit and repress others. Knowledge is anathema to these exploiters and repressors, and therefore they promote ignorance and prejudice, especially about human capabilities and the possibilities of social development. For democratically-minded progressives and liberals it is precisely this knowledge which is the key to effectual collective action and meaningful self-determination, in short, to progress. And thus we return to the social-historical context and role of comparative psychology. It alone, as conceived by Hobhouse, can provide the correct understanding of human psychological functioning needed for the conscious direction of the collective process, and therefore for real historical progress.

REFERENCE NOTES

1. Hobhouse's arguments supporting this interesting claim, form a large part of *Democracy and Reaction* (1904). It would go beyond the scope of the present article to repeat or even to summarize them. For present purposes it will suffice to appeal to the common intuition that there is at least *some* connection between foreign policy and some of the more disagreeable aspects of life at home and that ideological control at home is often linked to justification of policies abroad.
2. It is important to note here that Hobhouse is not rejecting "struggle" or natural selection as the dynamic of *biological* evolution. He claims simply that these concepts are inadequate to explain *historical progress*. His attempt to find an alternative explanation represents a particularly transparent example of his tendency to lapse into philosophical idealism, which resulted from a lack of clarity regarding ontology. He understood progress to result from an inexorable increase in "harmony" brought about by the Mind's essential tendency to "bring things together." In short, he was much clearer—and more correct—about what did *not* account for progress.

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COMPENSATION IN ABNORMAL CONDITIONS OF INFANT CARE IN THE COMMON MARMOSSET (*Callithrix jacchus*)

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SUMARIO: Filhotes do sagui comum (*Callithrix jacchus*) são cuidados pelo pai e pela mãe durante as primeiras semanas de vida, com predominância do cuidado pelo pai. Algumas famílias, no entanto, não seguem este padrão, e seu estudo permite uma melhor compreensão das alternativas à diminuição de cuidado aos filhotes. Três famílias de sagui comum (pai, mãe e gêmeos recém-nascidos) nas quais o pai mostrava níveis diminuídos de cuidado, e duas famílias que apresentavam o padrão usual de cuidado, foram observadas. Em duas das famílias de cuidado diminuído e uma das famílias normais, o pai foi removido 15 dias após o nascimento dos filhotes; nas outras duas famílias o pai foi removido 30 dias após o nascimento. Dados referentes à duração do cuidado pela mãe, cuidado pelo pai, e contato físico entre os gêmeos foram coletados do nascimento até dois dias após a separação. Embora as mães compensassem pelo cuidado diminuído dos pais, a quantidade total de cuidado não diferiu daquela apresentada na família normal, no caso das famílias de 15 dias. Já nas famílias de 30 dias, o tempo total de cuidado foi menor na família com baixos níveis de cuidado do pai quando comparado ao da família normal. O tempo de contato entre os gêmeos também diferiu entre as famílias de 15 e de 30 dias. Os resultados indicam que o cuidado compensatório pode ser induzido no sagui comum.

ABSTRACT: *Callithrix jacchus* (common marmoset) young receive care from mothers and fathers during early stages of development. In order to evaluate the compensatory care given by mothers when fathers were not giving their usual care, three families of marmosets, in which the fathers evidenced low levels of care from the time of the birth of the young, and two families in which the level of paternal care giving was normal were studied. In two of the low care families, and one of the normal families, the father was removed at 15 days after birth; in the other two families the fathers were removed at 30 days after birth. Data as to duration of care giving by the mother, care giving by the father, and contact between the two offspring (typically the

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Acknowledgements, the authors wish to express their thanks to Dr. Neil R. Chalmers for reading and providing valuable suggestions for the manuscript and for improvement of the English. Also to Neuciane Gomes da Silva for helping with statistics and preparation of the figures. This study was supported by grants from FINEP, CNPq, and UFRN.

common marmoset gives birth to twins) were recorded from the time of birth through two days after separation. Although the mothers compensated for the low levels of care given by the fathers, the total amount of time spent in care giving did not differ from that of the normal families, in those cases where separation took place at 15 days. In the case of the 30 day separation families, the total time of care giving in the low-care family was lower than that of the normal family. Contact time between twins also differed between the 15 and 30 day separation families. The results indicate that compensatory care giving can be induced in the common marmoset.

In the study of relationships between infants and their caregivers much attention has been directed lately to the *Callitrichidae* family, of the New World monkeys that show co-operative infant care (Epple, 1970, 1975; Hershkovitz, 1977; Hoage, 1981). Observations of the common marmoset (*Callithrix jacchus*) in captivity have shown that infants are cared for by all members of the family (Ingram, 1977; Locke-Haydon & Chalmers, 1983; Arruda, Yamamoto & Bueno, 1986), and the amount of care provided by each member varies with an infant's age (Locke-Haydon & Chalmers, 1983). However, there have been conflicting reports about the extent to which family members compensate for each other's behavior with respect to the infant. In particular, Ingram (1975), cited by Locke-Haydon (1984a, p. 806), reported that when one parent carried the infant for less time than usual, the other parent would compensate by carrying more. Locke-Haydon (1984a), by contrast found that mothers did not compensate when fathers had been given a tranquilizing drug. Locke-Haydon (1984a) also developed a model predicting the conditions under which compensation would be expected to occur, and under which conditions it would not.

Locke-Haydon's and Ingram's studies both involved families in which all members were allowed to remain in the group. By contrast, Arruda et al. (1986) carried out an experiment in which they removed the father from the family. Under such circumstances the mother compensated for the father's absence by increased amounts of carrying. Since removal of the father disturbs the family group far more extensively than merely drugging him, this compensatory response might have resulted from the disruptive effects of his removal rather than the absence of paternal carrying. To test whether the mother would compensate for a low level of paternal care when the father was present in the cage, parental groups in which paternal care was at a low level were studied.

METHOD

Animals

Five families of *Callithrix jacchus* from the Center of Primatology of Universidade Federal do Rio Grande do Norte, consisting of a reproductive pair and newly-born twins were observed. The parents were all wild-born and first-

time parents in captivity. Each family lived in cages (60 x 75 x 100 cm) in a room with controlled temperature and a 12 h light/dark cycle. Animals were fed twice a day, at 0900 and 1500, one meal consisting of fresh fruits and the other of a protein mixture. Animals were not manipulated, except for washing of cages, every three days, when they were removed for a few hours.

Three of those families presented an unusual pattern of infant care, in that the father provided very little care to the infants. The reason for this lack of caregiving by the father was not quite clear to us, and was investigated separately (Silva, Yamamoto & Arruda, 1987). The two other families were considered normal because the levels of infant carrying by the father did not differ from those in the majority of families in our laboratory (Arruda et al., 1986) and those reported by Ingram (1977). In these families, the levels of father carrying were also higher than that of the mothers' in the first weeks of the infants' lives, as was found by Locke-Haydon and Chalmers (1983).

Procedure

In order to evaluate compensation by the mother for the diminished care in the father's absence, data were gathered during the father's presence and during periods of separation. So that the results could be compared with an earlier experiment (Arruda et al., 1986) the fathers were removed for either 15 or 30 days. Two low-care families (LC1 and LC2) and one normal family (NC1) had their fathers removed for 15 days; the third low-care family (LC3) and the other normal family (NC1) had the fathers removed for 30 days.

Families were observed from the birth of infants until two days after the return of the father. Behaviors observed were:

1. the time the infants were carried by the mother (time on m) or by the father [time on p];
2. the time the infants were not being carried [time off];
3. the time the infants were in physical contact with each other during time off.

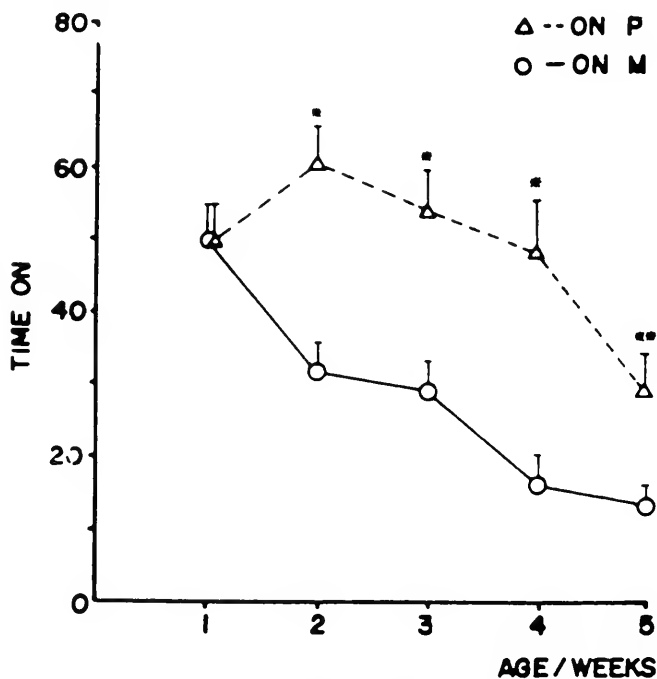
Animals were observed three days a week, for 30 m sessions, except at preseparation (two days), separation (three days) and post-separation (two days), when they were observed twice a day, for 30 m sessions. Observations were made between 0800 and 1800, the first in the morning, the other in the afternoon.

RESULTS

For comparative purposes, Figure 1 presents the mean percentage of time on m and time on p for 11 families in our colony, per 7-day observation period. A fuller description of these 11 families and the procedure used to observe them are described elsewhere (Arruda et al., 1986). Levels of father's and mother's care and infants' contact in families LC1, LC2, and LC3 (Fig. 2) were compared with those of standard families NC1 and NC2 (Fig. 3).

Time on p and time on m are similar in the first week, but from the second to the fifth weeks time on p is significantly higher than time on m. Most of the families in our laboratory show a similar pattern of care, as shown in families NC1 and NC2 (Fig. 3). Prior to separation in these families, time on p was higher or at least equivalent to time on m. This result is characteristic of the prevalence of care by the father at the beginning of life. A completely different pattern, though, is presented by the "abnormal" families LC1, LC2, and LC3 (Fig. 2) in which the relationship between behavior by the father and mother was inverted, particularly in the first three weeks of life. This inversion was attributable to a decrease in father carrying, which in some cases was nil.

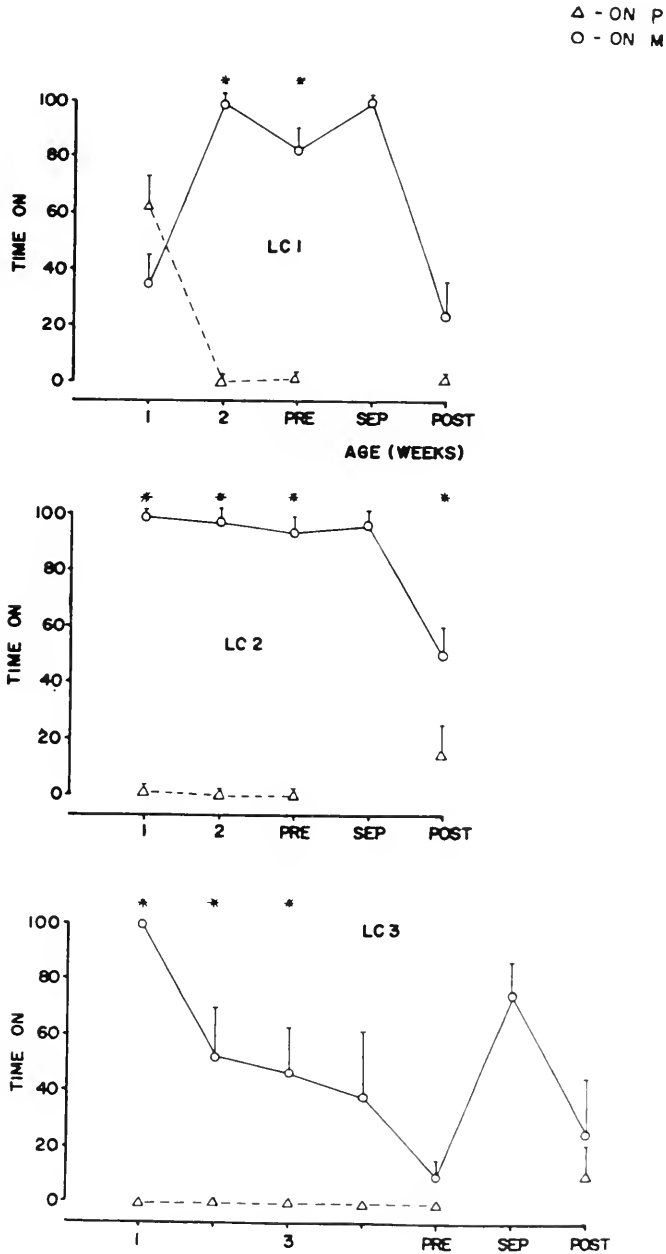
FIGURE 1. Mean percentage of time on p (father) and time on m (mother) for families LC1 (top), LC2 (middle) and LC3 (bottom); preseparation, separation, and postseparation periods. Vertical lines represent 1 SEM.



* $p < 0.05$; Student's t -test for nonindependent groups

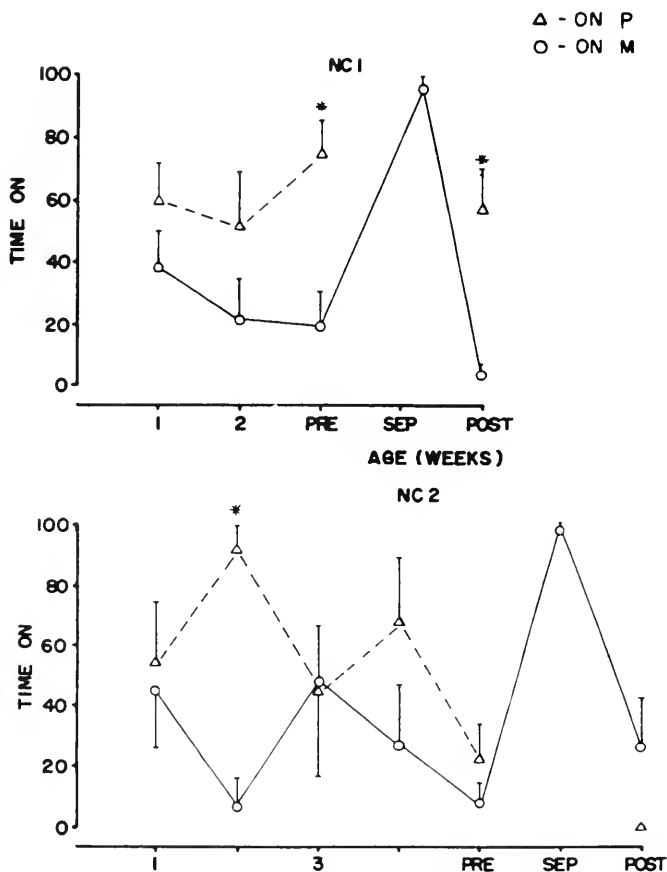
Diminished father care in the "abnormal" families was compensated for by augmented mother care in the second week and preseparation period in the LC1 family, and in the first and second weeks and preseparation and postseparation periods in the LC2 family, when compared to time on m in NC1 family; and in the first and second weeks in the LC3 family when compared to NC2 family (all differences are significant at the 0.05 level in student's t -test for independent groups).

FIGURE 2. Mean percentage of time on p (father) and time on m (mother) for families NC1 (top) and NC2 (bottom); preseparation, separation, and postseparation periods. Vertical lines represent 1 SEM.



* $p < 0.05$; Student's t-test for nonindependent groups

FIGURE 3. Mean percentage of time on p (father) and time on m (mother) for 11 families, from first through fifth week, per seven day observation period. Vertical lines represent 1 SEM.

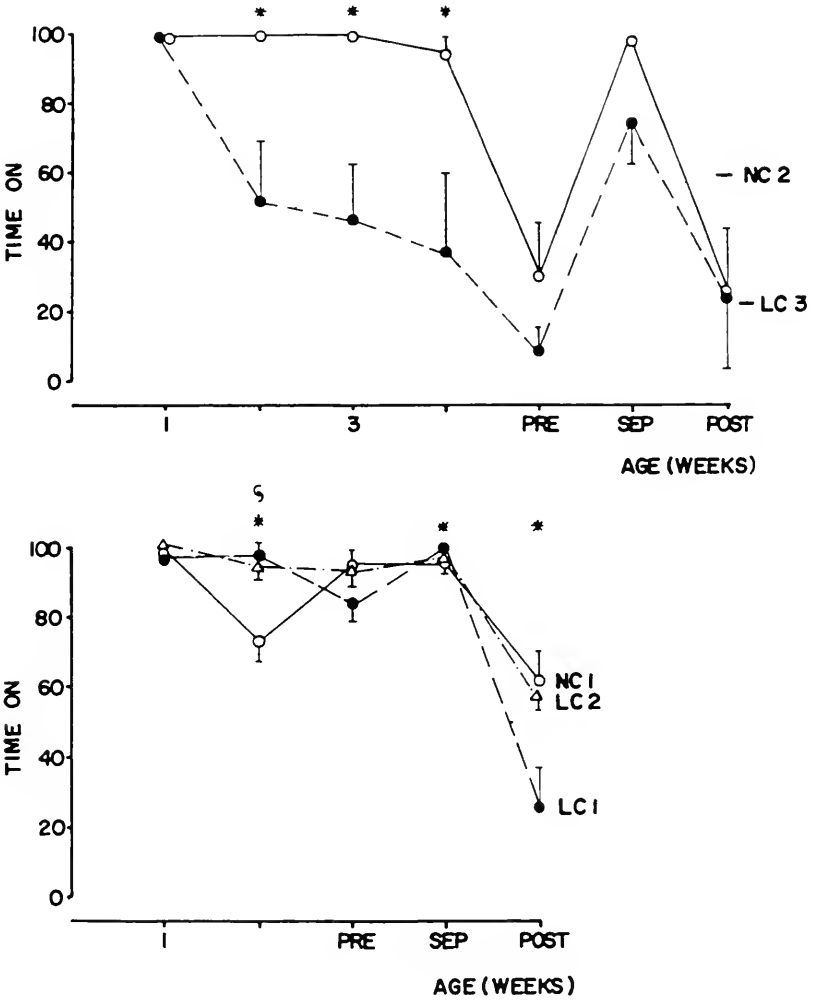


* $p < 0.05$; Student's t-test for nonindependent groups

** $p < 0.01$

In spite of the differences in the sharing of father and mother carrying in the LC1 and LC2 families when compared to NC1, those differences were not apparent when the time mother carries is added to the time father carries the infants. As seen in Figure 4, the percentages of total time on (mother plus father) for families LC1, LC2 and NC1 are very similar. The significant differences, with one exception (LC1 in the postseparation period), occur surprisingly, when the "abnormal" families' mean exceeds the normal family mean. So, the differences between mother and father carrying with the 15-day separation in the normal and low-care families did not alter the total time the infants were carried.

FIGURE 4. Mean percentage of total time on (mother plus father) for families NC1, LC1 and LC2 (bottom) and for families NC2 and LC3 (top). Vertical lines represent 1 SEM.

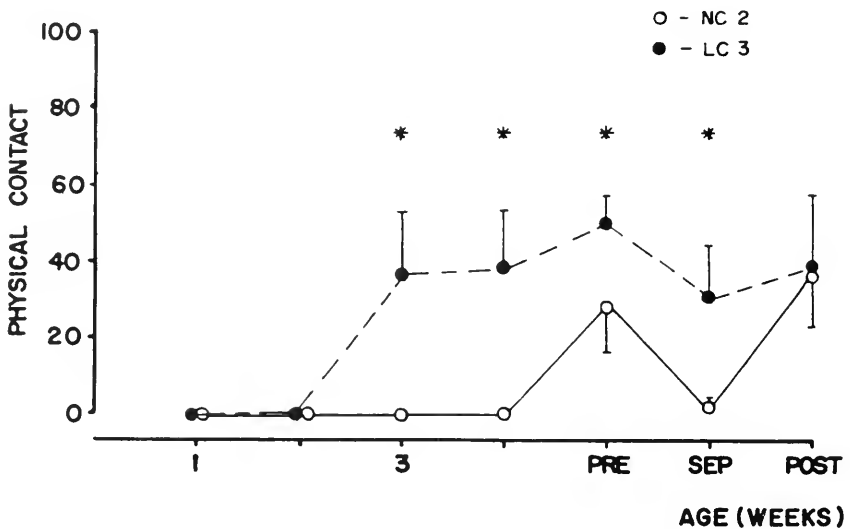


* $p < 0.05$; Student's t-test for independent groups

This was not found in regard to the 30-day separation. Figure 4 shows that the altered pattern of care in the LC3 family altered also the total time infants were carried when compared to NC2 family. The virtual lack of father carrying in LC3 family (Fig. 2) had a clear effect on total time on, from the second to the fourth weeks. In these weeks the infants in the NC2 family were carried significantly more than infants in the LC3 family.

The data for physical contact between twins is also different in the 15 day and 30 day separation families. NC1, LC1 and LC2 families show

FIGURE 5. Mean percentage of twin physical contact for families NC2 and LC3. Vertical lines represent 1 SEM.



* $p < 0.05$; Student's t-test for independent groups

equivalent amounts of physical contact by the infants. Figure 5 shows that during the third and fourth weeks, and during the preseparation and separation periods, physical contact between the twins in the LC3 family was significantly higher than between the twins in the NC2 family. Figure 5 also shows that physical contact appeared earlier for the twins of the LC3 family, as the percentages for the NC2 family twins are zero until the preseparation period.

DISCUSSION

Our results show that during first and second weeks the mother compensates for the reduction in the father's care, at least at the beginning of an infant's life. It is important to note, though, that *Callithrix jacchus* families normally include more than one set of offspring, and care by older siblings could prevent compensation by the mother.

Our data are not quite compatible with the Locke-Haydon model (1984a) of care-giving/care-seeking balance in *Callithrix jacchus*; she believes that compensation is not expected to occur if the level of care-giving offered by parents falls below that sought by infants. We have no data on levels of care-seeking by the infants, and it is quite possible that the care offered exceeded the care sought, thus predicting compensation.

Given the rather drastic change in the mother's carrying behavior in the low-care families, we believe that she increased the amount of care she would usually offer. Evidence for a change in the mother's disposition to offer more care is given by Arruda et al. (1986) who report not only an increase in time on m when the father is removed, but also an increase in the mother's tolerance of the infants, which is indicated by a sharp reduction in rejection scores. So, it is likely that the removal of the father or the absence of care, as in the low-care families, alters the amount of care offered by the mother, thereby changing the balance of care-giving/care-seeking.

A fundamental variable concerning compensation is probably age of the infants. Locke-Haydon (1984a) drugged the father and siblings at 4 and 14 weeks respectively. Our study shows that compensation occurred mostly in the first two weeks. Alterations in care-giving patterns occur from the time of the infants' birth, and it is possible that compensation occurred in response to the father's behavior, and decrease in compensation from the third week on may represent an adaptation in the mother's behavior.

The first weeks of life seem to be very important in the relationship of father-mother and infants, and Ingram (1977), Locke-Haydon and Chalmers (1983) and Arruda et al. (1986) report that through the second week of life infants are carried most of the time by one or the other carrier, or both, except for brief periods. Thus, up to this age infants usually do not experience diminished care by one of the care-givers, but experience rather an increase in one or the other care-giver's carrying. At four weeks of age, and more clearly at 14 weeks, there is a decrease in care behavior, (Locke-Haydon 1984a); this probably is not a critical event, as the infant shows more diversified behavior allowing other kinds of compensation. Studies of the motor and social development of infant marmosets report that at four weeks they show good coordination and locomotory behavior, as well as complex social behavior mainly restricted to the twin (Stevenson & Rylands, in press; Yamamoto, Arruda & Bueno, 1986).

Physical contact seems to be a rather good substitute for reduced care. Locke-Haydon and Chalmers (1983) and Moreira (1986) report an increase in the time spent with the twin in infants with a highly rejecting father or mother. The same thing happened in family LC3, exactly at the time when the mother ceased to compensate for the father's diminished care. In Locke-Haydon's study (1984b) the drugged fathers, although more passive toward the young, did not show any decrease in the time they carried or spent with the infants. This finding suggests that some kind of physical contact was provided by the drugged fathers, and even though it may not have been qualitatively the same as that provided by normal fathers, it may have been sufficient to rule out the need for compensation by the mother. This situation resembles the cloth

substitute mother described by Harlow (1958, 1959), which, although passive, provided contact-comfort for the young macaques.

In conclusion, the present results suggest that with more critical reductions in care than those presented in Locke-Haydon's study (1984a), and at a more precocious age, it is possible to induce compensation in the common marmoset (CcF, Locke-Haydon, 1984a; and Arruda et al. 1986).

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Acknowledgements, the authors wish to express their thanks to Dr. Neil R. Chalmers for reading and providing valuable suggestions for the manuscript and for improvement of the English. Also to Neuciane Gomes da Silva for helping with statistics and preparation of the figures. This study was supported by grants from FINEP, CNPq, and UFRN.

EARLY LEARNING CAPABILITY IN RODENTS: A REVIEW (*Rattus norvegicus* and *Mus musculus*)

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ABSTRACT: Available data on learning capabilities in immature rodents are briefly summarized and some new findings on early learning in mice are presented. We omit the comparatively small number of works concerning precocial species of rodents, that is, guinea pigs and spiny mice. In a comparison we have already made (D'Udine and Alleva, 1983) we found that rodent species characterized as precocial types appeared to be affected in a dramatic way by environmental factors during postnatal development, as shown by profound modification of their adult behavioral patterns. Since the aim of our contribution is to review the methodological paradigms used to assess early learning capabilities in rodents, we shall focus here on the Norway rat and the house mouse, because they are the only species for which evidence has progressively been built up through the use of different tests.

SOMMARIO: I roditori di laboratorio hanno rappresentato storicamente il materiale di base sul quale sono stati sviluppati i paradigmi sperimentali dell' "apprendimento" animale. E' stata posta relativamente troppa attenzione su un numero estremamente ridotto di specie, per di più tra loro simili, il che ha causato parecchie restrizioni nel definire leggi più generali sull'apprendimento. Tale atteggiamento è stato criticato ma ci si è occupati molto meno di un altro tipo di distorsione causata dall'uso di animali adulti, e della conseguente costruzione di modelli molto poco validi per stadi immaturi.

Un esame critico della letteratura mostra che con l'uso di saggi appropriati possono essere evidenziate capacità di apprendimento anche nel periodo perinatale. Vengono anche discussi aspetti comparativi e altri riguardanti lo sviluppo ontogenetico nelle specie ratto e topo.

Sono riportati alcuni dati originali nel topo, specie sulle cui capacità neonatali di apprendimento e ritenzione esistevano solo risultati negativi.

ONTOGENY of LEARNING and RETENTION CAPABILITIES in the NORWAY RAT (*Rattus Norvegicus*)

We have restricted our field of interest to the preweaning period as far as the rat is concerned. Learning capabilities in the rat around

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Acknowledgements. We thank Carla van Vlaanderen for helping with the drafting of the manuscript and Piezluigi Meloni for editing the text.

the weaning period have been extensively studied in the past, and there is good evidence of full-fledged capabilities as early as ten days of age (Goldman and Tobach, 1967). The considerable developmental transitions occurring in the early stages of altricial rodents have been carefully described by Rosenblatt (1976, 1983) who defined three major stages, according to the sensory motor capabilities of the developing organism, in particular, the preeminent role played by thermotactile and olfactory stimulation. Therefore, we shall discuss here only data collected before the tenth day of age.

We shall also omit all papers where the authors used available methods to analyze the outcome of manipulations aimed at interfering with a normal path of development. In other words, all the papers where learning capabilities were used as developmental markers for pharmacological or toxicological treatments are not considered here.

The aim of our review is mainly to stress the evolution of the methodology that has been used to assess learning capabilities in pups, in order to show that the demonstration of more precocial capabilities parallels the use of more appropriate tests to check them. In order to cope with the considerable literature which has increased over the last few years, we have roughly classified works in this field into four main categories, albeit with some minor methodological heterogeneities.

1. Motor response following footshock
2. Aversion for a set of novel stimuli
3. Conditioning through suckling response
4. Conditioned aversion to olfactory or gustatory cues

The first category "Motor response following footshock," includes tests ranging from simple forelimb withdrawal of immobilized rats suspended in a harness, to complex locomotor requirements, such as escape responses in unidirectional and multidirectional tasks. We stress that we are dealing here with footshock as an unconditioned stimulus (US) because it has been demonstrated that an interoceptive electrical stimulation (as intraperitoneal shock) produces very different results from an exteroceptive one (Haroutunian and Campbell, 1979). It is necessary to recall also that in tests requiring a certain level of locomotor capability as when the animals must proceed through an alley or a Y-maze, the pups often receive an additional rewarding unconditioned stimulus by being held in the warm hands of the experimenter for 30 seconds after the end of the test. The authors never openly discuss the possible joint effect of footshock and handling on their results.

The second category "Aversion for a set of novel stimuli," includes either neophobic reactions to novelty or, quite obviously, preferences for previously familiar conditions. In rodents, the developmental changes in neophobia have been thoroughly investigated as that set of precocial experiences defined as "imprinting" in the past. Our second category

therefore, subsumes the effects of various kinds of stimulation during the so-called "sensitive periods." This category includes goal-directed behavior towards the nest (homing behavior) and the aversive reactions to atypical thermic conditions. In one case thermal stimulation has been used also as reinforcement for instrumental conditioning (Guenaire et al., 1982b).

The third category "Conditioning through suckling response," includes more recent work and focuses on a particular behavioral item typical of the early stages of development. The suckling response is an adequate sensory motor response for altricial pups, since it occurs naturally in nest conditions. Furthermore, suckling occupies a key position in the hierarchical order of reactions for the survival of the pups (Blass and Teicher, 1980). Suckling, either rewarded or not by milk intake, has been therefore successfully used to show appetitive conditioning and instrumental learning capabilities.

Manipulation of the suckling response allowed associative capabilities to be demonstrated in very young rats and these assessments immediately follow the development of the technique of intraoral cannulation, first developed by Hall and Rosenblatt (1977). Suckling has been successfully employed to elicit and mold age-typical behavior responses such as rooting, pivoting, mouthing and probing, which in turn have been used to demonstrate learning capabilities.

The last category "Conditioned aversion to olfactory and gustatory cues," is again a newly developed technique, and the one that has so far given the best results because it has either made possible the proof of learning capabilities at very early ages, or it has shown retention for extremely lengthened intervals. In fact, only through the use of this technique has it been possible to prove prenatal capabilities of learning in rodents, as well as retention of learned aversion over periods of days or even weeks.

With the organization of the tests according to the above mentioned four categories, we summarize in Table 1 all the recent work in this field with the sole exception of the work of Moral et al., (1981) who have been able to prove associative learning and spatial discrimination in three-day-old pups in a task where brain self-stimulation was used as a reward during a single 18 hour session.

Table 1 shows early learning capabilities in the Norway rat, the most extensively studied rodent species. In this table we list a survey of the existing literature going back to 1962. The developmental ages considered start from the prenatal period, specifically the last two days of pregnancy, here marked as -2, up to postnatal day 9, an age at which some locomotor capabilities are detectable in the nest, while the full locomotor capacities and weaning occur at ten days of age or later.

To summarize the results of different studies, we use a "black dot" in the case of full-fledged learning capabilities, i.e., for clear conditioned responses retained for at least 24 hours. A question mark indicates

Table 1
Postnatal Day

	-2	-1	0	1	2	3	4	5	6	7	8	9		
1962			?										Caldwell et al.	0
			?										Caldwell & Werboff	0
1967			?		?			?					Gray et al.	0
1968						?							Thoman et al.	X
1970								?		?		?	Misanin et al.	0
1971				-	-	-	-	-	-	?	?	?	Gregory & Pfaff	X
								?		?		●	Misanin et al.	0
									?				Bulut & Altman	X
1973								?		?		?	Misanin et al.	0
1974								?		?			Misanin et al.	0
1976					●								Rudy & Cheattle	X
1977						?	?	?	?		?		Cornwell-Jones & Sobrian	X
										●			Kenny & Blass	0
										●			Cheatle & Rudy	X
										●		●	Hinderliter et al.	X
1978					●						●		Rudy & Cheattle	X
												?	Smith & Spear	X
			●		●	●	●			-		?	Spear & Smith	0
					-	-	?	?	?	?			Bachevalier & Blozowski	X
					●					●			Guenaire et al.	0
1979			?										Haroutunian & Campbell	X
						-				?	?	?	Johanson & Hall	0
					●		●		●		●		Martin & Alberts	0
								?					Rudy & Cheattle	X
													Gemberling et al.	X
1980						●		?		●		●	Johanson & Teicher	0
					●	-							Misanin et al.	0
													Smith & Spear	X
1981				●						?		?	Smith & Spear	0
							?	?	?	?	?	?	Gemberling & Domjan	X
				?	?	?	?	?	?	?	?	?	Guenaire et al., a	X
				-		●			●			?	Guenaire et al., b	X
1982						●	●		●				Johanson & Hall	0
						●	●						Martin & Alberts	X
						?							Pedersen et al.	0
	●												Smotherman, a	X
	●												Smotherman, b	X
	●												Stickrod et al.	X
1983					●					●			Rudy & Cheattle	0
						●							Smith et al.	X
1984				●		●			●			●	Johanson et al.	0
													Rudy et al.	X

● + conditioning retained for more than 24 hrs

? + conditioning retained for less than 24 hrs or unclear response

- + no conditioning was evident

0 + motor response following footshock

X + aversion for a novel set of stimuli

0 + conditioning through suckling response

X + conditioned aversion to olfactory or gustatory cues

unclear evidence or evidence of short-term retention. The minus sign is used only where the authors have been unable to prove learning. Vertical columns show the ages at which the tests were performed, on the horizontal, each line shows (at the left) the results of a single study, the authors, and, on the extreme right, a symbol indicating the kind of test used. Note that the four symbols correspond to the four categories of tests we have already presented.

As far as the demonstration of learning capabilities in immature rats is concerned, it is pretty evident that:

1. Good learning and retention capabilities were not proved in the first postnatal week, until fairly recent years, as shown in the table by the absence of black dots until 1977.
2. Since 1976, when the first breakthrough happened, the age of demonstrated learning and retention capabilities goes down until it reaches the prenatal period (day -2).
3. The evidence of early learning and retention parallels the use of more appropriate tests for the assessment of the capabilities of rat pups. This trend is clearly illustrated if you look at the last column on the extreme right where the four kinds of tests are listed. The two white symbols on the black field correspond to tests that are unsuitable for the age of the pups when tested, while the normal X and O correspond to more appropriate testing conditions.

It is evident that over the years there is a transition between the predominance of white symbols on a black field and the normal Xs and Os. Therefore it is worth stressing the correspondence between the conditioned aversion test (indicated in the table by Xs) and the demonstration of full-fledged capabilities at early stages. In summary, our table shows how a methodological evolution permitted a new insight into the learning capabilities of the pups.

In this section we shall try to illustrate the major methodological changes that resulted in such an evolution by means of the observations that were done and the discussion of those findings.

a) Quantity, Quality and Age-dependent Effectiveness of the Unconditioned Stimulus (US)

As far as footshock as US is concerned some papers analyzed the age dependent reactivity to comparatively ineffective USs. In 1983 Misanin and Hinderliter found no substantial age differences in footshock reactivity evidenced in the locomotor activity of rats aged 5-13 days, whereas younger rats typically had lower levels of activity than older ones. In two-day pups Haroutinian and Campbell (1979) analyzed

differences in reactivity to both foot and intraperitoneal shock over a large range of intensities (0–0.2 mA). They found that only intraperitoneal shock was effective as US in producing conditioned odor aversion. From a qualitative point of view, Haroutinian and Campbell found a high degree of similarity between two different kinds of interoceptive stimulation, i.e., intraperitoneal shock and intraperitoneal injection of lithium chloride (LiCl), an illness-inducing drug. Very recently Kucharski and Spear (1984) demonstrated the efficacy of footshock as US in six- and ten-day-old pups.

In 1980 Gemberling et al., demonstrated that an isotonic solution of LiCl was effective in producing conditioned aversion in pups, while the hypertonic LiCl solution was not. In a recent paper, Rudy and Cheatele (1983) examined the effects of preexposure to LiCl on learning capabilities in rat pups of different ages. They found a long lasting effect of LiCl preexposure only in the younger animals and attributed this to ontogenetic differences in the excreting processes.

The role of temperature as US has been more often discussed as an interacting agent than as a determinant one. Hinderliter et al., (1978) exposed pups to a cold metal grid and the poor results they obtained could be attributed to the "freezing" produced in young rats placed in hypothermic conditions in an unfamiliar environment. Martin and Alberts (1982) got similar results using a LiCl injection or a low temperature (10 C) as US. Guenaire et al., (1979) obtained good results using a thermotactile stimulation consisting of a warm air stream. In a series of studies using temperature as US, Guenaire et al., (1979; 1982a; 1982b) found a clear-cut age-dependent effectiveness of the stimulus. Johanson and Hall (1979) used milk to elicit appetitive responses and the combined role of temperature and milk delivery was investigated by Johanson and Teicher (1980). They reported that low temperature interferes with both levels of milk intake and activity, suggesting that milk might not be as reinforcing if presented in a cold environment. The combined effect of milk intake delivered directly from the nipple and LiCl intraperitoneal injection interfered dramatically with conditioning, lowering or canceling the effect of LiCl. It has been correctly observed that suckling behavior per se, even without nutritive consequences is reinforcing to rat pups. Therefore, it is possible that suckling reinforcement can override or neutralize the flavor-toxicosis association in young pups.

The activating effect of simple exposure to milk intake has been examined by Johanson and Hall (1982). These authors extensively studied ontogenetic changes in the effectiveness of the role of temperature and previous deprivation. Johanson et al., in 1984 carefully examined the age-specific response to milk ingestion with peculiar behavioral patterns of arousal that it elicits at different ages.

Stimulation of very young pups ends up with a high level of their arousal, age-specific responses, and ultrasound emission, the last being

used as a marker during learning and extinction (Amsel et al., 1977). Tactile or amphetamine-induced stimulation may act as powerful events in the odor conditioning paradigm, as Pedersen et al., demonstrated in 1982. An interesting result of this study was that tactile and amphetamine stimulation, if provided in combination, produced a complete disruption of the learning process but only at nest temperature and with a high level of CS intensity. On the other hand, caffeine, in spite of being effective at the age tested, did not produce the stimulating effect of amphetamine.

In some cases the results of arousal level induced by different kinds of stimulating US indicate that any external manipulation (for example, handling or simply moving the home cage) can have strong rewarding effects on the pups especially after previous isolation from the mother.

b) Quality and Age-Dependent Effectiveness of the Conditioning Stimulus (CS)

The sensory competence of rat pups is reduced in the olfactory and thermotactile stages (Rosenblatt, 1976; 1983). Obviously, therefore, vibrotactile stimulation provided by an audio-oscillator has been used since 1962 by Caldwell et al., in a classical conditioning paradigm through leg-flexion.

Bulut and Altman (1974) demonstrated clear age-dependent variations in the efficiency of tactile stimuli, which improved with age. A recent comparison between vibrotactile and olfactory CS (Johanson and Hall, 1982) shows a better efficacy of olfactory cues at least in the case of an ingestional response.

Qualitative differences in attractiveness among odors have been noticed several times during the development of the pups. Nest odor has been demonstrated to exert an increasing attraction on pups from birth to 17 days (Gregory and Pfaff, 1971). Cornwell-Jones and Sobrain (1977) demonstrated an inverted U-shaped trend in the attractiveness of nest odor, peaking at seven to nine days. In the same study these authors monitored the ontogeny of the unconditioned response to a currently used CS cue, lemon essence, in two strains of rat. In Wistar, but not in Sprague-Dawley rat pups, the olfactory cues provided by lemon exerted an aversive effect per se during ontogeny and it is worth noting here that this strain-dependent aversion effect was only evident in the six to eight day period. It has been discussed several times that different types of olfactory stimulation (as well as gustatory cues) exert an attractive or repulsive effect per se, so that the conditioned aversion paradigm may vary from an enhancing aversive property of CS to the counterbalancing of an attractive effect.

At this point, it is worth recalling that, owing to the dramatic differences in olfactory competence between human experimenters and

test animals, some "new" stimuli used as CS in the conditioning paradigm might be similar in quality or differ only in intensity with respect to odors already experienced by the animals. Johanson and Teicher (1980) demonstrated a clear aversion effect of cedar essence in pups while an almond-like odor (benzaldehyde) proved more attractive if compared with cedar, at least at the age of three days (Pedersen et al., 1982). Using two different kinds of olfactory cues, Martin and Alberts (1982) showed CS-specific heart rate changes, an observation that is in agreement with other data on the profound qualitative effects of different responses to particular olfactory cues.

CS intensity has been partially explored by Pedersen et al., (1982) whereas the duration of CS exposure has been studied by Rudy and Cheatele (1978; 1979). They demonstrated that longer CS exposure resulted in facilitation and that some effects were age-dependent. Subsequently Smith et al., (1983) analyzed the critical role played by the duration of olfactory CS exposure in rat pups as young as two days. Preexposure to CS has been discussed in terms of degree of "familiarity" of CS during CS/US pairing (Rudy and Cheatele, 1979) and in terms of the maturation of sensory or motivational systems that altered the saliency of the stimulus.

To conclude, it is also interesting to note that the capability of rat foetuses to detect odors while still *in utero* (Pedersen et al., 1983) has been demonstrated only after a conditioned aversion paradigm indicates associative processes between an olfactory-gustatory CS and drug-induced illness in such an early age (Stickrod et al., 1982; Smotherman, 1982a, b).

c) Conditions under which CS/US Pairing Occurs

Intertrial length (Gray et al., 1967) and the duration of CS/US intervals were examined by several authors (Caldwell et al., 1962; Smith et al., 1983; Rudy and Cheatele, 1979; Gemberling et al., 1980). Rat pups younger than five to six days did not seem to show "long delayed learning," i.e., the capability to associate CS preexposure to US if they are separated by a long time interval. The developmental influences of CS/US interval has also been examined by Smith et al., (1983).

Rudy and Cheatele (1983) discussed the ontogenetic differences observed after such different CS/US interval conditions as a joint function of time and developmental change in US efficiency. In the case of LiCl US, in fact, ontogenetic changes in the rate of excretion may confound the results obtained using different levels; so, it is quite difficult at this time to discern when CS and US exposure eventually overlap.

An important interaction between CS/US interval and the temperature at which conditioning occurs had already been noticed in 1962 by Caldwell et al., and concern about the critical role of temperature

during testing has increased over the years. According to several authors, a temperature lower than the one of the nest interferes with learning (Caldwell et al., 1962; Johanson and Teicher, 1980; Johanson and Hall, 1982; Hinderliter et al., 1978), a warm temperature improves the pups' capabilities. These observations led to the current use of incubators as the test environment or as enclosures where the animals were transferred when separated from the mother (in cases in which a deprived condition seemed necessary to enhance motivation). According to the above mentioned authors, some learning capabilities were detectable *only* in animals maintained at conditions of nest temperature and humidity.

Spear and Smith (1978) were the first to demonstrate the dramatically disruptive effects on learning performance of pups experiencing CS/US pairing *in isolation*. The simple presence of home cage shavings improves learning (Smith and Spear, 1981). Social isolation, more than the hypothermic effect due to separation from littermates, is the critical factor for such a disruption (Smith and Spear, 1980). The disruptive effect of social isolation has been explained in terms of high arousal state produced by separating the pups from their nest environment. Age-specific defense reactions (for example ultrasound emissions) seem to interfere with the "optimal" level of arousal required for learning. In other words, isolation stress may modify attentional processes and interfere with the channeling of arousal levels into more appropriate behavioral response (Smith and Spear, 1980; 1981).

Some results are strongly inconsistent with the idea of "emerging" learning capabilities during ontogeny, and it has often been suggested that specific factors acting on the CS/US association may play an important role. Age-dependent sensitivity to various environmental cues (including those provided by CS and US stimulation) has been invoked to explain apparently strange results. Pedersen et al., (1982) using two CS and three US had surprising results, obtaining facilitating or disrupting effects according to particular combinations of factors. Rudy et al., (1984) using a gustatory cue in a conditioned aversion paradigm, were unable to find learning capabilities at ages in which the same paradigm was successful using an olfactory cue as CS. Therefore the pairing of CS with LiCl injection seems to be different according to the quality of CS exposure. Haroutunian and Campbell (1979) showed differences in learning performances using various CS/US combinations, but Martin and Alberts (1979) and Guenais et al., (1982b) obtained the most surprising results involving learning capabilities that seem to be very strongly age-specific. It is likely that these capabilities are more clearly revealed at particular ages by specific combinations of CS, US, and conditions of CS/US pairing.

In connection with the different conditions at which CS/US pairing can occur, the uterine environment of the mother must be taken into account also. Only the skillful surgical manipulation described by Blass and Pedersen (1980) can permit intrauterine CS and US exposure.

d) *Test Used to Assess Learning and/or Retention*

As we stated previously, the majority of tests used in the early studies of the ontogeny of learning in rodents involved suspending and immobilizing the animals and subjecting them to footshocks of different intensities (Caldwell et al., 1962; Caldwell and Werboff, 1962). Also, in subsequent tests centered on an escape response, factors such as fatigue, habituation or locomotor requirements deviating from the natural repertoire of pups' responses made the assessment of learning capabilities dubious or impossible in the early stages of development. In particular, the so-called competing responses (a strongly age-dependent stereotyped locomotor response), make the evaluation of full-fledged learning and retention capabilities difficult since it competes with behavioral responses better suited to the requirements of the avoidance task (Misanin et al., 1971; 1974; 1980).

Recent tests have begun to use elements of the natural repertoire of the pups, such as head raising following thermotactile stimulation (Guenaire et al., 1982a); crowding, mouthing or probing behavior (Johanson et al., 1984). The authors use relative changes of elicitation of these typical neonatal patterns of response as a measure of conditioning, while Johanson and Hall (1979) have demonstrated instrumental learning at very early stages through the crawling behavior of the pups in an appetitively motivated task. Martin and Alberts (1982) used heart rate changes as a useful parameter of learning assessment.

Other tests used the dyadic mother/infant interaction to demonstrate modifications in the pups' approach to the mother. In particular, only recently has the role of pups' saliva (Teicher and Blass, 1976) and the joint use of olfactory and tactile cues (Larson and Stein, 1974) been studied in the process of nipple localization and orientation. This response has been fruitfully used by Kenny and Blass (1977); Stickrod et al., (1982) and Smotherman (1982b) to demonstrate conditioning. More recent data (Johanson et al., 1984) implicate a critical involvement of olfactory stimulation in the control of rat pups' suckling behavior.

The growing use over the past few years of the conditioned aversion paradigm indicates that olfactory stimulation is a highly suitable stimulus event to use in the case of newborn pups subjected to associative learning tasks requiring the retention of an olfactory preference over a relatively long period of time.

ONTOGENY of LEARNING and RETENTION
CAPABILITIES in the HOUSE MOUSE
(*Mus musculus*)

The total number of studies of the other extensively studied species of rodents, i.e., the house mouse, is much more restricted and focuses

Table 2

Evaluation of Learning and Retention in Mice Aged 3-13 Days
Postnatal Day

	2	3	4	5	6	7	8	9	10	11	12	13	
1970				0		0		0		0		0	Nagy Misanin & Newman*
1971		?		0		0		0		0			Nagy Misanin * Olsen*
1972		0		0		0		■		■			Nagy Misanin Newman Olsen & Hinderliter*
				0		0	0	●	●				Nagy Misanin & Olsen*
				0		0		0		0		0	Nagy & Misanin*
1973							0		●				Nagy Misanin & Wetzel*
						0	0	●	●				Nagy & Mueller*
								?		●		●	Nagy & Sandmann
1974						?		0		●		●	Nagy & Murphy
1975								0		●			Nagy
								●					Nagy*
1976								●					Nagy Anderson & Mazzaferri*
								0		●			Nagy Pagano & Gable
						?		●		●		●	Herman & Nagy
1977						0							Nagy Burley & Kikstadt*
1978						0				0			Ray & Nagy
1979													
1980													
1981										0	0		Lavooy Lavooy Hahn & Simmel

■ + conditioning and retention for more than 24 hrs
● + conditioning and retention for 24 hrs
0 + conditioning and retention for less than 24 hrs
? + no conditioning or unclear response
* + STRAIGHT ALLEY USED

on the range of age between postnatal days 3 and 13. All these studies use footshock as US and escape behavior or passive avoidance as test performance.

Table 2 shows the studies aimed to characterize the ontogeny of learning in mouse pups. The solid symbols refer to demonstration of retention capabilities for 24 hours or more. As indicated in Table 2, Nagy and co-workers described the increase in 24 hour retention performance in mice aged 9-11 days. Postnatal day nine was critical for the appearance of early retention capability in those cases in which a simple straight alley task was used (studies using a straight alley are marked in the Table with an asterisk after the name of the last author). A slight retardation in the appearance of 24 hour retention was evident when a more complex test (for example the T-maze test) was used. In the T-maze test in fact, pups nine days old were often unable to retain the correct turning choice while eleven-day-old pups were able.

Nagy et al., (1978) examined the relative aversion threshold for electric shocks administered from constant current or fixed impedance sources, and other studies examined the age-dependent effects of varying intensities of footshock (Nagy and Misanin, 1973; Nagy, 1975, 1976; Nagy et al., 1978) on both escape performance and intrasession improvement. Age-related differences in motivational level were also noticed.

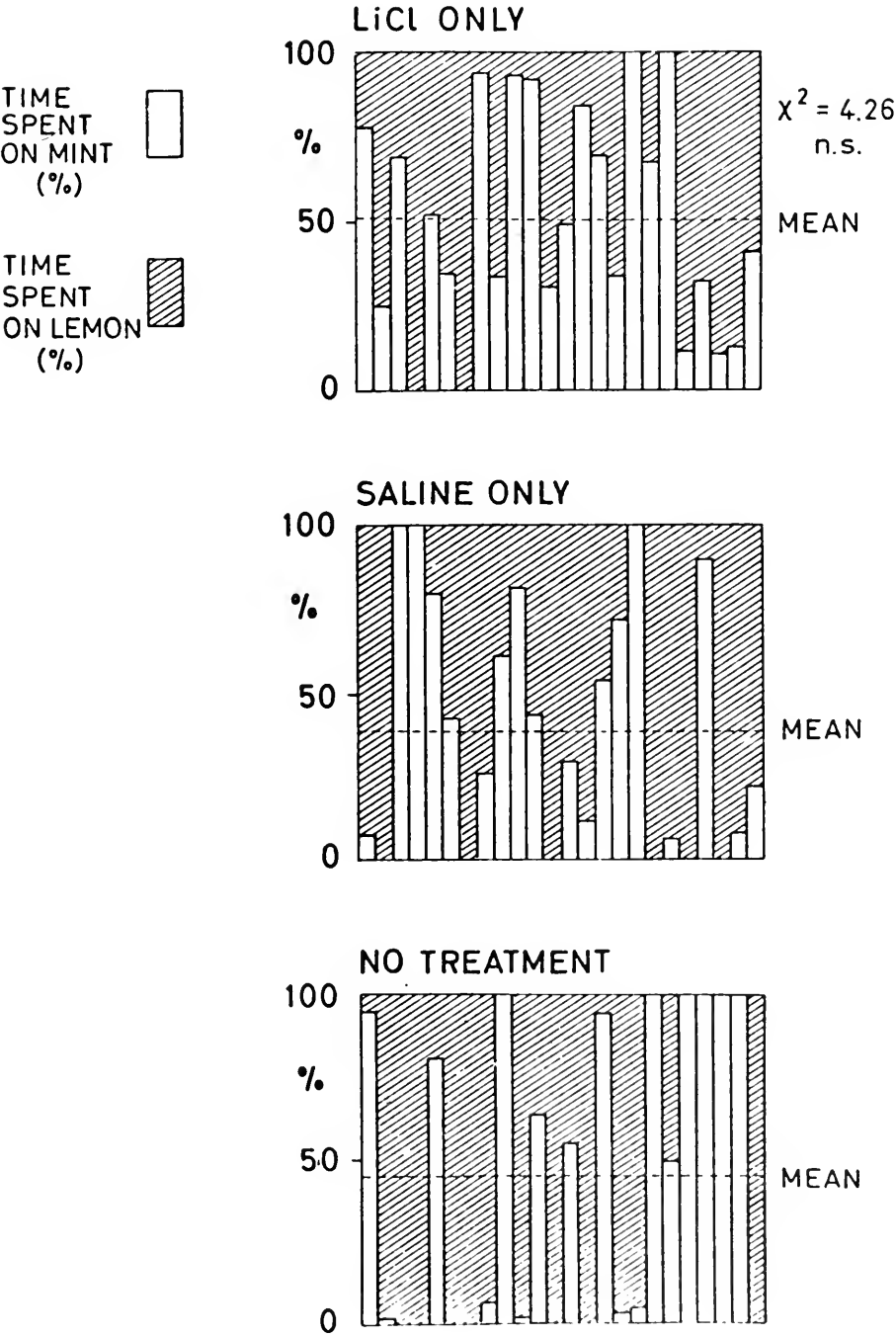
The amount of footshock-elicited competing response varies largely with age, with a clearly evident peak at day nine in several studies (Nagy et al., 1972a, 1971b; Nagy, 1976). Particular combinations of factors gave apparently strange results. For example, Nagy et al., (1973) obtained better learning in younger mice in tasks where the mice received a great number of trials. Herman and Nagy (1977) found performances that decreased with age in a particular strain. Furthermore, Ray and Nagy (1978) showed decreased learning performances in mice between seven and fourteen days in a passive avoidance task. The deviations have been readily explained as a joint function of age-typical behavioral responses and of nonmonotonic trends in various test factors.

On the whole, the data on mice did not show full-fledged learning capabilities in pups younger than nine days and give the impression of a limited range of testing conditions.

Recently, Alleva and Calamandrei (1983) applied the conditioned aversion technique to mice in an attempt to demonstrate earlier learning capabilities. In their experiment, the pups were exposed at the age of seven days to a conditioned aversion paradigm. Two olfactory CS (mint or lemon essence) and LiCl 0.2 M, 0.2% body weight (an illness-producing US) were used. All the mice were tested three days later in a two-choice olfactory test, where performance for a novel or LiCl-paired olfactory stimulus was measured over a 180-second session.

Figure 1 presents the data for three control groups having experienced only LiCl injection (top), only saline injection (middle), or which had been left undisturbed (bottom). None of the pups of these

Figure 1. Olfactory preferences of ten day pups pre-exposed three days before to: LiCl only; saline only; no treatment.



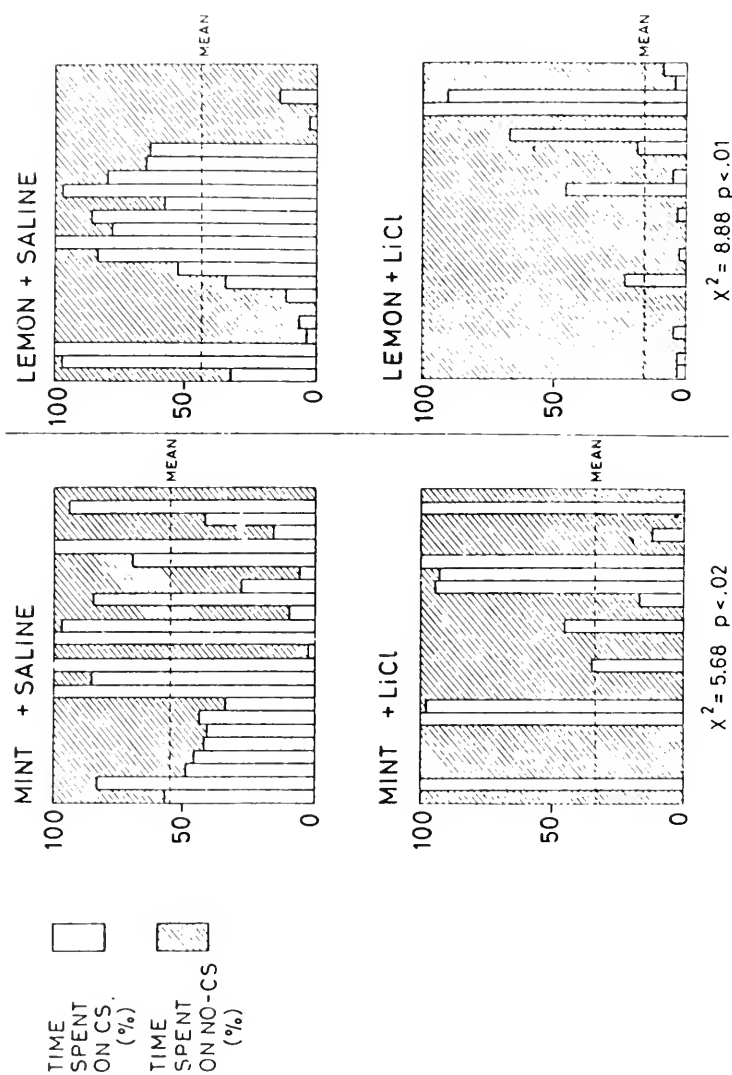


Figure 2. Olfactory preferences of ten day pups pre-exposed three days before to: mint and saline; mint and LiCl; lemon and saline; lemon and LiCl.

groups had been exposed to an olfactory CS. Individual scores for 24 pups in each group are shown and the mean of the group is reported as a dotted line. No differences were evident among the three groups and only a slight aversion for the lemon essence was present in the groups shown in the middle and bottom of the figure.

Figure 2 presents groups in which olfactory pre-exposure to mint or lemon were paired either with saline or LiCl injection. In both groups in which the CS was paired with US (lower part of the figure) a conditioned odor aversion is clearly evident, as is shown by the lowering of the mean line in both groups. The group that experienced lemon essence as CS showed a stronger effect. This is the first demonstration of a long-term retention in mice stimulated as young as seven days and confirms the validity of the conditioned aversion paradigm for revealing early learning capability in altricial rodents.

CONCLUSION

Early learning capabilities of pups may be better assessed using tests suited to age-dependent skills, and results may be explained in terms of nonmonotonic changes in the effectiveness of factors interacting with the developing organism. Profound differences in the processes underlying learning and retention performances must obviously exist, as discussed in the recent chapter by Norman Spear and David Kucharski (1984) and Zolman (1983) on the ontogenetic differences in stimulus selection during conditioning.

In recent years, there has been a growing acceptance of the idea that the maturation of the sensory and perceptual capacities of developing animals should be analyzed in greater detail and that those should be related to the ontogeny of learning and memory in each sensory channel. The characterization of the sequential development of response repertoires will expand the spectrum of behaviors that can be acquired.

Also, recognition that ecological considerations are relevant is generally more manifest, i.e., there is awareness of the fact that the developing animal faces changing ecological challenges at different points in its ontogeny (Spear, 1984). In the words of Byron Campbell in his 1984 essay *Reflections on the Ontogeny of Learning and Memory*, "the delineation of sequential sensory, central, and motor capacities and their interrelation to learning and memory should lead to an exciting decade of research in developmental psychobiology."

In the study of the "emerging" capabilities in altricial rodents, the considerations expressed by Bateson (1981) with regard to taking into account the different "larval" stages through which mammalian species pass during ontogeny seem particularly relevant. In invertebrates each developmental stage is clearly defined as in the case of caterpillar/butterfly transition. Similarly, a tadpole is not generally considered an

incomplete and incompetent version of a toad. In the case of the assessment of early learning capabilities in rodents, it sometimes seems that an attempt has been made to specify the "emerging flying capabilities" of an immature butterfly while forgetting the locomotor problems of being a caterpillar.

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CONTEXT LEARNING IN THE MARSUPIAL (*Lutreolina crassicaudata* Red Opossum)

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ABSTRACT: Context learning was studied in the Red Opossum, the marsupial, *Lutreolina crassicaudata*. In Experiment 1 the animals received four trials per day in two different boxes (contexts): X and Y. Half of the animals received periodic deliveries of a sugar solution (+) in one box (X+), but not in the other (Y-); the rest received the opposite training (X-), (Y+). Several behavioral categories were recorded during the final trial in each context. Animals approached the feeder significantly more in the positive context. Experiment 2 was designed to determine the extent to which the number of trials per day affected acquisition. Two groups of animals received differential training with either four or one trial per day. No differences between groups were observed, although in both of them, approach to the feeder was significantly higher in the positive context. The results are discussed in relation to both the role of practice distribution on learning in marsupials, and their potential value of this species for the study of learning processes.

RESUMEN: Se estudió el aprendizaje contextual en la zarigüeya colorada *Lutreolina crassicaudata*. En el Experimento 1 los animales recibieron cuatro ensayos por día en dos diferentes cajas de condicionamiento (contextos): X e Y. La mitad de los animales recibían periódicamente un monto de solución azucarada en una caja, X+, pero no en la otra, Y-; el resto de los animales recibían la contingencia opuesta, X-, Y+. Durante el último ensayo en cada caja se registraron varias categorías de comportamiento. Los animales se acercaron al bebedero significativamente más en el contexto positivo. El Experimento 2 fue diseñado para determinar hasta que punto el número de ensayos por día afectó la adquisición. Dos grupos de animales recibieron entrenamiento diferencial ya sea con uno o cuatro ensayos por día. No se observaron diferencias entre grupos, aunque en ambos casos el acercamiento al bebedero fue significativamente más frecuente en el contexto positivo. Los resultados se discuten tanto en relación con el papel de la distribución de la práctica sobre el aprendizaje en marsupiales, como con el valor potencial de estas especies para el estudio de los procesos de aprendizaje.

Associative and cognitive capabilities of marsupials are poorly known despite the potential importance of this group from the comparative point of view (Bitterman, 1986; Papini, 1986). For instance, most of the experiments on Pavlovian conditioning in marsupials lack appropriate

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Acknowledgements, this research was supported by grants from Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina. The authors wish to acknowledge Daniela Brunner and Marcelo Cassini for valuable comments on earlier versions of this manuscript.

control conditions to eliminate nonassociative factors (Papini, 1986). Recent evidence, however, suggests that at least two species, *Lutreolina crassicaudata* (Red Opossum) and *Didelphis albiventris* (White-eared Opossum) can be trained under several standard situations, such as differential conditioning, summation, discrimination reversal, and single alternation (Papini, in press a, b). It is worth considering here that these results encourage not only the comparative study of learning, but also open the way for a systematic research on two aspects to which marsupials are well suited: developmental and neuropsychological processes of learning.

In the present article, we report a successful attempt at studying another standard conditioning phenomenon: context learning. Learning about the static, continuously present cues of the environment began to be investigated to a large extent because of a successful model of Pavlovian conditioning that assumed contextual and discrete stimuli to be equivalent (Rescorla & Wagner, 1972). Because the events of any learning situation always occur on a background, the potential relevance of context learning is general (Balsam, 1985). Moreover, if contextual and discrete stimuli are equivalent, the principles of Pavlovian conditioning may be considerably more general than it was previously thought.

EXPERIMENT 1

Animals. Eight red opossums (*Lutreolina crassicaudata*), four males and four females, all adult, wild-caught, and experimentally naive, were studied. Initial weights were as follows: 900–2150 g for males; 500–600 g for females. Sexual dimorphism in body size is usual in this species. They lived in individual cages with food continuously available. One week before the first session, the opossums began to receive a limited amount of water daily (100 ml); during the experiment, subjects were allowed to drink during a maximum of 30 m per day. Access to water occurred at least 15 m after the session was over.

Apparatus. Two conditioning boxes (i.e., X and Y) were used, which differed in terms of visual, auditory, and tactile cues. These were located at different heights from the floor and were differently oriented in the room. Table 1 summarizes the features of each box.

Delivery of the unconditioned stimulus (US: 3% commercial sugar mixed by weight with tap water) was automatically controlled by standard relay equipment located in an adjacent room. Control and experimental rooms were separated by one-way windows.

Procedure. The animals received four trials per day with an intertrial interval (ITI) of approximately 20 m during which they were placed back in their cages. Each trial lasted 10 m. In the initial two trials of day one, the opossums were exposed to each context (order of exposure counterbalanced) without receiving

Table 1
Characteristics of the Boxes (Contexts) Used
in Experiments 1 and 2

	<i>Context X</i>	<i>Context Y</i>
Long x Wide x High	54 x 33.5 x 31 cm	42 x 35.5 x 55 cm
Floor	Translucent acrylic	Aluminum bars
Lateral Walls	Red vertical lines on white background	Aluminum
House Light	25 W	3.6 W
Light Module	Off	Two yellow lights, 3.6 W each
Feeder	2 cm diameter, to the right side of the box's door	6 cm diameter, to the left side of the box's door
White Noise	70 dB, S.P.L.	Off
Distance from the Room Floor	110 cm	150 cm

Legend. White noise was on in context Y during Experiment 2. Context validity was counterbalanced within groups in both experiments.

USs. In trials three and four, the animals were placed in the positive context, half the animals in X+, and half in Y+. They received a total of 30 ml of sugar solution in five deliveries.

From day two to six, animals received four trials per day; two trials were reinforced (R) and two nonreinforced (N). One of the following sequences of trials was used in each day: RRNN, RNRN, NRRN, NRNR, and RNRN. In an R trial animals received 20 USs, 1.4 ml each, according to a variable time (30 s) schedule. In an N trial subjects remained in the box during 10 m and received no USs.

Behavioral recordings were carried out during the last two trials of the last day of training. During the initial 2 m, and before any US was delivered in the case of positive contexts, two experimenters recorded the following categories:

1. Orient—head oriented toward the frontal wall with at least the forelimbs within the half of the floor closest to the feeder.
2. Feeder—head on the feeder.
3. Quiet—complete absence of movements.
4. Ambulation—movement of at least two limbs.
5. Grooming—scratch or wash any part of the body with hindfoot.

- 6. "Sleep"—quiet with eyelids closed.
- 7. Head-Jerks—rhythmic head movements in the saggital plane.
- 8. Rear—standing on hindlegs; forelegs may or may not be touching a wall.

Recordings were based on an instantaneous sampling of each box every 10 s, which gives 12 recording periods for each animal during the first two minutes. Only one category was recorded in a given sampling period. Overall interexperimenter reliability was 96.4%.

Table 2
Mean Proportion of Recording Periods
in which each Behavioral Category was
Recorded in Relation to Experiment 1

<i>Category</i>	<i>In the Positive Context</i>	<i>In the Negative Context</i>
Orient*	.50	.05
Feeder	.26	.05
Quiet	.52	.54
Ambulation	.01	0
Grooming	.08	.25
"Sleep"	0	.05
Head-Jerks	.01	.08
Rear	.02	0

* $P < 0.01$

RESULTS AND DISCUSSION

The results obtained in each dependent measure are presented in Table 2. Two categories yielded consistent results across subjects: Orient and Feeder. In both cases, the proportion of recording periods in which each category was recorded in relation to the total number of recording periods was higher in the reinforced than in the nonreinforced context. One-factor, repeated measures analyses of variance for each category indicated that the proportion of Orient behavior was significantly higher in the positive context [$F(1, 7) = 13.96$; $p < 0.01$]; Feeder was only marginally different across contexts [$F(1, 7) = 4.17$; $p < 0.10$]. None of the other categories yielded significant differences.

This experiment shows that associatively based context conditioning can be observed in red opossums and that it is measured by a tendency to orient and approach the feeder in the positive context. Apparently, contextual stimuli do not control head-jerk movements, a behavior observed in conditioning experiments with discrete visual and auditory signals (Papini, in press a). These results also contrast with those obtained in pigeons (Durlach, 1983) and rats (Mustaca, Gabelli, Charabuki, & Papini, 1987) which in analogous situations display conditioned activity in positive contexts.

EXPERIMENT 2

In two prior investigations in our laboratory, we attempted to contextually condition red opossums using one trial per day in visually different contexts or in olfactorily different contexts. We were unable to do so. The negative results may have been obtained because (1) the contexts were not sufficiently discriminable, or (2) the training was too spaced. The choice of one trial per day was based on a similar experiment on pigeons reported by Rescorla, Durlach, and Grau (1985), where they observed rapid context discrimination using activity as the dependent measure. However, there are some suggestions in the literature that opossums (*D. virginiana*) learn faster under massed rather than spaced trial conditions (Friedman & Marshall, 1965; Tilley, Doolittle, & Mason, 1966). For instance, Friedman and Marshall found little within session improvement in a successive reversal task with few trials per day, but relatively good performance when subjects received as many trials as needed to achieve a behavioral criterion. Although these experiments are difficult to interpret because they did not control for the effect of accumulated training per se, it is still possible that spaced practice adversely affects performance in opossums (see also Cone & Cone, 1970).

The results of Experiment 1 suggested that our prior unsuccessful attempts to obtain contextual learning in red opossums might have been caused either by the use of relatively similar contexts or by the use of a relatively distributed practice. The latter factor seemed worthwhile pursuing further in light of the seemingly beneficial effect of massed practice on discrimination learning in Virginia opossums (Friedman & Marshall, 1965; Tilley et al., 1966). Also, the literature suggests that at least in some situations (i.e., autoshaping of the pigeon's key-peck response) acquisition speed is inversely related to the number of trials per session under both continuous and partial reinforcement (Papini & Overmier, 1984, 1985). Experiment 2 was designed to replicate differential conditioning and to compare acquisition under either one trial (spaced) or four trials (massed) per day.

Animals and Apparatus. Eight adult, experimentally naive, wild-caught red opossums (4 males, 4 females) were studied. Initial weights were: 400–700 g for males and 280–390 g for females. Maintenance and deprivation conditions were similar to those in Experiment 1 except that after five days of training, because signs of satiety were observed, access to water in the cage was restricted to 15 m for the Spaced Group (one trial per day) and 5 m

for the Massed Group (four trials per day). Conditioning chambers were the same as those used in Experiment 1 except that background white noise was delivered in both of them (Table 1).

Procedure

Training was divided into two phases. In phase one, the procedure was that used in Experiment 1 except that behavior was recorded during the initial 90 s of each trial, and that only the following categories were noted: a combination of Orient plus Feeder; Quiet; and Grooming. In addition, animals received a 10% sugar solution rather than a 3% sugar solution as in Experiment 1. Half the animals received four trials a day as in Experiment 1, and half received one trial a day (Massed Group and Spaced Group respectively). During Phase 1, animals received 20 USs (1.4 ml each) in R trials, on a VT 30 s schedule.

Some procedural modifications were introduced in Phase 2 because we observed signs of satiety in the Massed Group and because the opossums approached the feeder mainly after the noise produced by the solenoid valve that delivered the US. Accordingly, the number of USs was reduced from 20 to 10 per trial (trial length was reduced to 5 m) and the solenoid valve was activated during both positive and negative trials, but only in the former was the US delivered. Behavioral recordings were similar to those of Phase 1. Phase 2 lasted 20 trials (10 R and 10 N trials). Interobserver reliability was calculated on 15% of the trials, and it was 95%.

RESULTS AND DISCUSSION

During Phase 1, some animals from the Massed Group were reluctant to drink the sugar solution, particularly during the third and fourth trial of each day. Because sugar solutions of even lower concentrations are known to be potent USs (Papini, in press a) we interpreted this observation as a sign of satiety. The approach to the feeder only after the noise produced by the solenoid valve suggested that there was in fact a salient discrete signal in the situation that could possibly block context conditioning (e.g., Durlach, 1983). Despite these problems, Orient and Feeder behavior appeared consistently and significantly more in positive than in negative contexts in both groups [$F(1, 6) = 8.70$; $p < 0.025$], although groups were not different from each other in this behavior. These results are presented in Table 3. As expected from Experiment 1, neither Quiet nor Grooming exhibited differential scores between contexts or between groups (p 's > 0.05).

Table 3 also shows the results of Phase 2. No evidence of satiety and control by the noise of the solenoid were observed in Phase 2, with ten (instead of 20) USs per trial and the solenoid activated in R and N trials (instead of only in R trials). Again, there was a significantly higher proportion of Orient behavior in positive contexts [$F(1, 6) = 26.87$; $p < 0.01$] but the groups were not statistically different from each other. As Table 3 also shows, however, the difference in Orient

Table 3

**Group Means for each Behavioral Category
Recorded in Experiment 2**

<i>Category</i>	<i>Spaced Group</i>		<i>Massed Group</i>	
	+	-	+	-
Phase 1				
Orient**	.39	.08	.21	.11
Quiet	.18	.14	.27	.13
Grooming	.24	.48	.32	.30
Phase 2				
Orient***	.61	.04	.41	.16
Quiet	.20	.39	.18	.12
Grooming	.06	.33	.19	.23

*+: Positive context; -: Negative context.

** $P < 0.025$

*** $P < 0.01$

behavior between contexts was larger for the Spaced Group than for the Massed Group, a result evident from a marginally significant Groups by Contexts interaction [$F(1, 6) = 4.36$; $p < 0.10$]. No differences were found in Quiet and Grooming.

GENERAL DISCUSSION

The present experiments were intended to provide evidence of contextual learning in red opossums. The observation of differential conditioning together with the appropriate counterbalance of context validity across subjects supports the conclusion that behavioral changes were associatively based. Therefore, the range of conditioning phenomena is expanded as demonstrated in this didelphid marsupial, (see also Papini, in press) using training procedures which are flexible enough to allow the use of these species for comparative, developmental, and neuropsychological studies of learning.

Durlach (1983) observed more activity in a positive context in pigeons and rats. The increased activity cannot be attributed to US delivery since it was measured at the start of each session and before the animal received the first US. Moreover, it cannot be explained in nonassociative terms because they used differential training procedures. The present results agree with their general conclusions thus showing that direct control of performance by contextual cues seems to be a fairly general phenomenon.

In addition, these results show that general activity may not be the only index of contextual learning in appetitive situations. The red opossums showed no differences in ambulation but they oriented and approached the feeder mainly in the positive context. We still do not know whether these performance differences are a function of the kind of stimuli in each context, described in rats for discrete signals of food (Holland, 1977), the type of US, or if they simply depend on the freezing tendency of wild red opossums. For example, in discrete-trial differential training with visual and auditory signals, red opossums reared under laboratory conditions showed goal approach in positive trials and goal withdrawal in negative trials; however, goal withdrawal during negative trials was substantially reduced in wild-caught red opossums (Papini, *in press a*). The topography of anticipatory responses to the sugar solution also differs between contextual and discrete signals, whereas in the former red opossums simply orient and approach the feeder, in the latter they display rhythmic movements of the head in the sagittal plane directed toward the feeder (Papini, *in press a*).

The absence of a trials-per-session effect is not in agreement with discrimination experiments with Virginia opossums (Friedman & Marshall, 1965; Tilley et al., 1966) that found better performance under massed practice i.e., many trials per session. Thus, the claim that Virginia opossums in particular, and marsupials in general, differ from other mammals in their memory mechanisms (cf. Tilley et al., 1966) is not supported by the present results. If anything, it appears that contexts were more discriminable under spaced than under massed practice; the lack of a significant interaction (see Table 3, Phase 2), might be related to the small sample size or to possible differences in motivational level across groups.

These results also contrast with the effect of the number of trials per session found in discrete-trial experiments with pigeons (Papini & Overmier, 1984, 1985). There are important procedural differences that prevent a full understanding of this discrepancy, such as the use of different species (pigeons versus red opossums) and different kinds of signals (discrete versus contextual). This pattern of results suggests the possibility that learning about contextual and discrete signals might be differentiated, at least with regard to the distribution of trials per session.

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BOOK REVIEW

E. Tobach, editor
*Historical Perspectives and the
International Status of Comparative Psychology*

This book represents "The Proceedings of the First (Toronto, 1982) and Second (Acapulco, 1984) Conferences of the International Society for Comparative Psychology (ISCP)." The book has two major sections—Part I: Historical Perspectives, all written by North Americans and Part II: International Status of Comparative Psychology, all but one from non-North American countries.

There is a sense in which we are all comparative psychologists since "Earlier in the century, the definition was much broader, emphasizing race, child and individual differences, as much as animal psychology" (Innis). Hence, this reviewer, while not a comparative psychologist was delighted to receive a fine scholarly refresher course plus an updating of new historical information and a realization that the tensions in comparative psychology as now understood continue to reflect the schisms in the entire discipline, i.e., some form of dualism in the Cartesian tradition versus the monism or naturalism aspired to by systematic behaviorism.

In comparative psychology the tensions are considered to result in a "current identity crisis" (Demarest) such that "comparative psychology in the Netherlands is threatened with extinction, just as in the U.S.A." (Nijssen and Van Rijswijk); this "crisis in comparative psychology is' a theoretical one, one that will require some fundamental changes in our thinking in order to attain a solution" (Tolman). Hence the historical perspective expressed in several of the chapters is a quite appropriate focus for understanding the roots of the current tensions.

In fact, accepting Cartesian assumptions logically militates against comparative psychology as we have come to recognize it. Ardila, in his chapter on comparative psychology in Latin America, writes that in the last century "as taught to students in the schools of philosophy and medicine, the 'soul' was a unique characteristic of human beings, and animals did not have it. To study the psychology of animals would have been a logical impossibility. Animals also did not have 'souls', and because psychology was the study of the soul, animal psychology did not exist." I am reminded that DesCartes' famous paper on the operation of the pineal gland in human psychology was titled "*On the Passions of the Soul.*"

Demarest's chapter called "Two comparative Psychologies" gave me a *deja vu* experience. I used to tell my classes that the Cartesian formulation placed all other species save humans in the category of mere automata but that only we could learn and be rational since only we had souls or minds. Hence the revolutionary notions of psychological continuity proposed by Darwin, also discussed in this book, and the empirical observations of learning in other animals by Pavlov, Thorndike, and others posed a problem for theoretical positions. Either DesCartes was wrong and other species do have minds or souls (cognitive psychology) or he was wrong that humans do have minds or souls (Behaviorism). Demarest puts in this way:

This became the first great problem for comparative psychology. How does an evolutionary psychology explain the origins and evolution of mental life from life that is otherwise insensitive. By the early 1900's there were three alternative explanations; (a) grant consciousness to all animals, (b) grant consciousness only to those animals whose behavior reveals attributes regarded as evidence of mind, or (c) deny that *any* animal exhibits consciousness." (emphasis added)

Demarest goes on to discuss in depth the elaboration of these themes in the hands of Jennings and Loeb.

I was further enlightened by Furumoto and Scarborough's chapter, "Placing Women in the History of Comparative Psychology: Margaret Floy Washburn and Margaret Morse Nice." It is difficult to fathom why women are underrepresented in this field—after all, a good psychologist is, well, a good psychologist. In some future conference I hope someone will undertake to present the contributions of Florence Gelber and Elaine Kinder (as well as the editor of this volume, Ethel Tobach).

Not being a comparative psychologist I am in no position to define the field and therefore establish the criteria of what belongs in it, but I was struck by the absence of any reference Winthrop Kellogg and his wife L.A. Kellogg who raised a chimp (Gua) and their child (Donald) together in as identical conditions as was then possible. Their findings were reported in their book, *The Ape and The Child*, (1933). Such direct species comparisons seems to me to qualify for inclusion as a contribution to the history of comparative psychology. Could this research be receding in to non-history? The last text that I know of which made systematic use of the Kelloggs' data was Pronko & Bowles *Empirical Foundation of Psychology* (1951).

My final comments have to do with the laboratory control of behavior as regards comparative psychology. The reductionism of Loeb, Watson and other earlier behaviorists is quite reasonably criticized. However, they did point toward the potential of sophisticated control of individual behavior which is a hallmark of successful scientific achievement. Evolutionary influences have not been emphasized along with experimental rigor but

rather than criticize "the fact that comparative psychology has too often been associated with learning theory . . ." (Demarest) I would hope that comparative psychologists would incorporate that data into a broader perspective. Nature cannot be at odds with herself so a comprehensive theory must allow all legitimate data to be included. I am reminded here of Skinner's discovery of the power of operant shaping. This is not limited to the laboratory. C. Lloyd Morgan beautifully described it in 1909 by observing his fox-terrier adaptively learn to retrieve a heavy-knobbed stick over successive throws after an hour or two which he completely explained in terms of "sense experience" and the center of gravity combined with "trial and error." The generality of the process might still escape us if Skinner had not confined rats to an operant chamber.

Space does not allow me to refer to other important contributions contained in this volume: Zoological inputs, the history of the use of captive animals, and the contributions of R.M. Yerkes and E.C. Tolman plus the status of the field in other Non-U.S. countries not previously mentioned. These subjects are all treated successfully. This is an excellent selection of papers which should be suitable for use in upper-division courses or graduate seminars after a student has had a course in history and or systems of psychology.

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